

AD-A158 595

EVALUATION OF TWO CONCEPTS FOR REDUCING SEDIMENTATION
AT MAYPORT NAVAL STATION(U) NAVAL CIVIL ENGINEERING LAB
PORT HUENEME CA J A BAILARD ET AL. JUL 85 NCEL-TN-1725

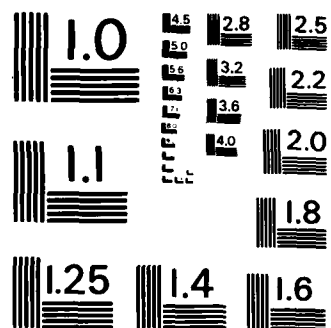
1/1

UNCLASSIFIED

F/G 13/2

NL

						END							
						FILED							
						DTIC							



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A158 595

DTIC FILE COPY

TAQINHS

TN NO: N-1725

TITLE: EVALUATION OF TWO CONCEPTS FOR REDUCING
SEDIMENTATION AT MAYPORT NAVAL STATION

AUTHOR: James A. Bailard and Scott A. Jenkins

DATE: July 1985

SPONSOR: Naval Facilities Engineering Command

PROGRAM NO: Y1316-01-006-610

NOTE

**NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043**

Approved for public release; distribution unlimited.

**DTIC
ELECTE
AUG 2 9 1985**
S D
G

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons	0.9	tonnes	t
	(2,000 lb)			
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft ³	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

When You Know	Multiply by	To Find	Symbol
LENGTH			
millimeters	0.04	inches	in
centimeters	0.4	inches	in
meters	3.3	feet	ft
meters	1.1	yards	yd
kilometers	0.6	miles	mi
AREA			
square centimeters	0.16	square inches	in ²
square meters	1.2	square yards	yd ²
square kilometers	0.4	square miles	mi ²
hectares (10,000 m ²)	2.5	acres	
MASS (weight)			
grams	0.035	ounces	oz
kilograms	2.2	pounds	lb
tonnes (1,000 kg)	1.1	short tons	
VOLUME			
milliliters	0.03	fluid ounces	fl oz
liters	2.1	pints	pt
liters	1.06	quarts	qt
liters	0.26	gallons	gal
cubic meters	35	cubic feet	ft ³
cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (exact)			
Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

*1 in = 2.54 (exact). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.26, SD Catalog No. C13.10-286.



Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AD-A158595

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1 REPORT NUMBER TN-1725	2 GOVT ACCESSION NO. DN487312	3 RECIPIENT'S CATALOG NUMBER
4 TITLE (and Subtitle) EVALUATION OF TWO CONCEPTS FOR REDUCING SEDIMENTATION AT MAYPORT NAVAL STATION		5 TYPE OF REPORT & PERIOD COVERED Final; Oct 1983 - Sep 1984
		6 PERFORMING ORG. REPORT NUMBER
7 AUTHOR(s) James A. Bailard and Scott A. Jenkins		8 CONTRACT OR GRANT NUMBER(s)
9 PERFORMING ORGANIZATION NAME AND ADDRESS NAVAL CIVIL ENGINEERING LABORATORY Port Hueneme, California 93043		10 PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS 63725N; Y1316-01-006-610
11 CONTROLLING OFFICE NAME AND ADDRESS Naval Facilities Engineering Command Alexandria, Virginia 22332		12 REPORT DATE July 1985
		13 NUMBER OF PAGES 60
14 MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15 SECURITY CLASS (of this report) Unclassified
		15a DECLASSIFICATION DOWNGRADING SCHEDULE
16 DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18 SUPPLEMENTARY NOTES		
19 KEY WORDS (Continue on reverse side if necessary and identify by block number) Sedimentation, prevention, basin, tidal flushing, venting canal, Mayport Naval Station		
20 ABSTRACT (Continue on reverse side if necessary and identify by block number) Two concepts for reducing sedimentation in the turning basin at Mayport Naval Station were evaluated using a simplified box model methodology. The two concepts included a shallow venting canal and an extension to the entrance channel jetty. The simulation model predicted that an optimally-sized venting canal would reduce the rate of sedimentation in the turning basin by approximately 60%. This result, however, was found to be particularly sensitive to uncertainties in the input data set. In contrast, the		

DD FORM 1473

EDITION OF 1 NOV 55 IS OBSOLETE

Unclassified

continued

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. Continued

simulation model predicted that the proposed jetty extension would reduce the sedimentation rate by 85%. This result was not as sensitive to the uncertainties in the data set. With the relative cost of the canal being approximately one-tenth that of the jetty extension, the higher degree of uncertainty associated with the canal is offset by significantly higher potential cost savings.

Library Card

Naval Civil Engineering Laboratory
EVALUATION OF TWO CONCEPTS FOR REDUCING SEDIMENTATION
AT MAYPORT NAVAL STATION (Final), by J. A. Bailard and S. A. Jenkins
TN-1725 60 pp illus July 1985 Unclassified

1. Sedimentation 2. Tidal flushing I. Y1316-01-006-610

Two concepts for reducing sedimentation in the turning basin at Mayport Naval Station were evaluated using a simplified box model methodology. The two concepts included a shallow venting canal and an extension to the entrance channel jetty.

The simulation model predicted that an optimally-sized venting canal would reduce the rate of sedimentation in the turning basin by approximately 60%. This result, however, was found to be particularly sensitive to uncertainties in the input data set. In contrast, the simulation model predicted that the proposed jetty extension would reduce the sedimentation rate by 85%. This result was not as sensitive to the uncertainties in the data set. With the relative cost of the canal being approximately one-tenth that of the jetty extension, the higher degree of uncertainty associated with the canal is offset by significantly higher potential cost savings.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

CONTENTS

	Page
INTRODUCTION	1
OBJECTIVE	2
APPROACH	2
MEASUREMENTS AND PROCEDURES	3
Entrance Channel Velocities and Concentrations	3
Volume and Sediment Fluxes	5
Total Dynamic Head	8
In-Situ Bulk Densities	10
SIMULATION MODEL	10
DISCUSSION	19
CONCLUSIONS AND RECOMMENDATIONS	21
REFERENCES	23

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A/1	



INTRODUCTION

Mayport Naval Station Mayport, Fla, is faced with a serious maintenance dredging problem. Mayport Naval Station has an average annual dredging requirement of 448,000 m³/yr (Hoffman, 1980). The unit cost of dredging presently ranges between 3 and 5 \$/m³ and has been rising steadily. Dredge material disposal is another pressing problem. Recent estimates suggest that the remaining lifetime of the dredge material disposal area is 2 years. Once that area is full, either a new disposal area will have to be found or the material will have to be disposed of at sea. Both alternatives will be costly.

Two possible solutions to the above problems have been proposed. They are: to construct a 580-meter (1,900-foot) jetty extension from the end of the carrier berth peninsula; and to construct a shallow venting canal connecting the northwest corner of the turning basin to the St Johns River. The jetty solution was recommended by the U.S. Army Engineers Waterways Experiment Station (WES, 1979) on the basis of a movable bed model study; the latter was recommended by Scripps Institution of Oceanography (SIO), Jenkins et al., (1983), on the basis of several field studies at Mayport.

The two proposed solutions differ significantly in terms of approach and cost. The jetty extension is a passive approach that creates a buffer volume of water which isolates the basin from the river. The venting canal is a dynamic approach which acts to supply the basin with relatively sediment-poor water from the surface of the river in place of the sediment-rich water entering via the entrance channel. The estimated cost of the canal is approximately one-tenth that of the jetty extension.

Mayport Naval Station has recently submitted a Military Construction (MILCON) project application for the canal. This application has generated a number of questions regarding the expected efficiency of the proposed canal in reducing sedimentation and the optimum size for the

proposed canal. The purpose of the present study was to answer these questions and similar questions relating to the proposed jetty extension. This study was sponsored by the Naval Facilities Engineering Command under the Engineering Investigation (EI) program.

OBJECTIVE

The primary objective of the study was to evaluate the expected efficiency of the proposed venting canal and determine its optimum size. A secondary objective was to perform a similar analysis for the proposed jetty extension. Satisfying these objectives required measurement of the sediment flux entering the turning basin and a more complete examination of the sea level inequality which develops between the basin and the river. The time history of the sediment flux was necessary for estimating the impact of the proposed venting canal and jetty extension on the sedimentation rate in the basin. Data on the difference in water levels between the basin and the river were needed to optimize the size of the proposed canal.

APPROACH

The Naval Civil Engineering Laboratory and Scripps Institution of Oceanography conducted a joint field study of the shoaling processes in Mayport turning basin. The field study focused on measuring: (1) water velocities and sediment concentrations in the turning basin entrance channel; (2) water levels in the St Johns River and the turning basin, near the location of the proposed venting canal; (3) bottom velocities and sediment concentrations in the river near the entrance to the proposed canal; and (4) predredged soil densities at points throughout the turning basin. Data were measured for a period of one tidal cycle on 1 Apr 1984.

The measurements obtained in this field study were used in conjunction with field data measured by Jenkins et al., (1983) to estimate: the rate of suspended sediment flux into and out of the basin as a

function of time; the total dynamic head available to the canal as a function of time; the conversion factor for computing the volume flux of sediment from the weight flux of sediment; and the estimated efficiencies of different sized canals and entrance jetties in reducing rate of sedimentation in the Mayport turning basin. The following is a discussion of the velocity and concentration measurements and the methods which were used to estimate the above quantities.

MEASUREMENTS AND PROCEDURES

Entrance Channel Velocities and Concentrations

The suspended sediment flux passing into or out of the turning basin at any given moment, SF_e , is the spatial integral of the product of the local instantaneous water velocity and the local instantaneous suspended sediment concentration. In practice, this integral is difficult to estimate because the velocity and concentration are measured at a few discrete points in space and time.

In the present study, water velocity (U) and suspended sediment concentration (C) were measured at two stations located on the flanks of the entrance channel (see Figure 1). At each station current meters were positioned at the top and bottom of the water column while a boat was used to gather water samples at four points within the water column (see Figure 2). The sampling interval for the current meters was 1/2 second, with the mean recorded every 10 minutes. Suspended sediment concentration profiles were obtained every 20 minutes.

The above data were used to construct time series of water velocity and sediment concentration, which were representative of surface and bottom conditions on the north and south sides of the entrance channel to the basin (see Figure 2). In all cases, a common designation of 1 to 4 was used with 1 and 3 referring to the north and south surface quadrants and 2 and 4 referring to the north and south bottom quadrants. Positive velocities are directed into the basin.

Figure 3 shows a plot of the two surface and two bottom velocities measured in the entrance channel to Mayport turning basin. The corresponding suspended sediment concentration measurements are shown in Figures 4 and 5. For both the suspended sediment concentration and the velocity data, a complete tidal cycle is shown (approximately 12.3 hours); however, a portion of the data shown (approximately 2030 to 2140 hours for the velocity data and 0930 to 1200 hours and 2020 to 2140 hours for the suspended sediment concentration data) had to be estimated due to delays in deploying several of the instruments. (Note that data for a complete tidal cycle were needed to compute the flux estimates).

Examining Figure 3, several interesting features can be seen in the velocity records. First, the magnitude of the surface currents were significantly greater than those of the bottom currents. Second, the bottom currents began flowing into the basin approximately 2 hours before the surface currents. When the surface currents did begin to flood, the onset was very rapid, particularly on the south side of the entrance channel. This was visually evident during the study when foam lines from the zone of shear at the river/entrance channel interface were swept into the basin. Visual observations also confirmed that the transition from ebb to flood conditions was delayed 30 minutes on the north side of the channel, with the transition taking place more gradually.

Flood currents lasted approximately 4 hours beginning at low tide (1400 hours) and ending at 1800 hours. At this point, the surface currents abruptly switched to ebb flow, with the bottom currents following a short time later. The brief, but intense ebb flow at the surface lasted approximately 3 hours followed by a 5-hour period of relatively weak ebb flow. Bottom currents followed a similar pattern except that the period of intense ebb flow lasted several hours longer.

The suspended sediment concentration data shown in Figures 4 and 5 were found to exhibit a high degree of variation. Peak concentrations were found to be as great as 0.075 gm/liter, with more frequent peaks in the 0.04 to 0.05 gm/liter range. The highest peaks occurred during the brief but intense period of flood currents. During ebb flow, lesser peaks were measured. These were perhaps the result of earlier flood

peaks being advected back out of the basin. In general, however, the suspended sediment concentration levels occurring during flood flow were found to be significantly greater than those during ebb flow.

On the south side of the channel (Figure 5), the top and bottom suspended sediment concentrations were found to be well correlated. In fact, Figure 5 shows them to be nearly identical, except at late ebb tide (1230 hours) when the bottom concentrations exceeded surface concentrations by a factor of 3. On the north side of the channel (Figure 4), the surface and bottom concentrations were also found to be correlated, except during early flood (1400 to 1500 hours) when the bottom concentrations led the surface concentrations by approximately 1 hour. The latter might be explained by the nearly 2-hour lead in the bottom currents relative to the surface currents at the onset of flood flow. The leading bottom currents would act to bring the high concentration sediment originating at the river/channel interface to the lower profiling stations sooner than to the surface stations. During ebb, the top and bottom concentrations were found to be closely correlated, except during late ebb when the bottom concentrations exceeded surface concentrations by approximately 0.01 gm/liter.

Volume and Sediment Fluxes

The following equation was used to estimate the volume flux of water (Q_e) in the entrance channel:

$$Q_e = (W_t A_{et}) U_t + (W_b A_{eb}) U_b \quad (1)$$

where A_{et} is the cross-sectional area of the entrance channel above -5 meters MLLW, A_{eb} is the cross-sectional area below -5 meters MLLW, $U_t = (U1 + U3)/2$ and $U_b = (U2 + U4)/2$ are the average measured velocities at the top and bottom, and W_t and W_b are weighting factors needed to convert the measured velocities to the spatially-averaged velocities representative of the upper and lower cross-sectional areas (1030- and

985-m² respectively). Figure 6 shows a plot of U_t and U_b as a function of time. Note that for simplicity, the variation of A_{et} with the tide has been neglected.

Least squares estimates of W_t and W_b were obtained from continuity and Equation 2 using the measured velocities, U_t and U_b , and the predicted tidal prism. This procedure required that the integral of Q_e over the period of flood tide be equal to the tidal prism of the basin. Similarly, the integral of Q_e over the complete tidal cycle was required to be equal to zero, i.e.,

$$\int_0^{T/2} Q_e dt = A_p (\eta_{bHi} - \eta_{bLo}) \quad (2)$$

and

$$\int_0^T Q_e dt = 0. \quad (3)$$

where T is the tidal period, A_p is the plan area of the basin; and η_{bHi} and η_{bLo} are the water elevations in the basin at high and low tide respectively. The resulting estimates for W_t and W_b were found to be equal to 0.174 and 0.154 respectively.

Figure 7 shows the volume flux, Q_e as a function of time. The peak channel flow rate was found to be approximately 90 m³/sec during ebb flow. During flood flow, a value of 88 m³/sec was reached; however, the duration of peak flow was maintained for a longer period of time. A noticeable feature of the estimated volume flux record is the rapid onset of flood flow and the equally rapid change to ebb flow.

Modifying Equation 2, the dry weight flux of sediment passing through the entrance channel, SF_e , was estimated as:

$$SF_e = (W_t A_{et}) U_t C_t + (W_b A_{eb}) U_b C_b \quad (4)$$

where $C_t = (C1 + C3)/2$ and $C_b = (C2 + C3)/2$ are the average suspended sediment concentrations at the top and bottom of the channel.

Figure 8 shows a plot of C_t and C_b as a function of time. Similarly, Figure 9 shows a plot of the surface and bottom contributions to the sediment flux. Clearly, most of the suspended sediment flux is occurring in the upper portion of the water column. Summing the surface and bottom fluxes, Figure 10 shows a plot of the total estimated suspended sediment flux as a function of time. The suspended sediment influx was found to occur as two distinct peaks, the first reaching a value of 3.1 kg/sec during early flood and the second reaching a value of -2.5 kg/sec during late flood. The ebb suspended sediment flux also contained two peaks, however, they were spaced more closely together in time. Integrating the sediment flux over the complete tidal cycle led to an estimated net flux of 6,400 kg of dry sediment into the basin. This is equivalent to a net influx of 68 m³ of sediment, based on the measured bulk densities of the sediments in the basin.

Apparently shoaling conditions on 1 Apr 1984 were weak, for the average shoaling rate based on annual dredging records is 614 m³ of sediment per tidal cycle. Most likely, the shoaling in Mayport turning basin is episodic with high rates of shoaling occurring during periods of high sediment abundance in the river. Alternatively, the present method of estimating the sediment flux into the basin may have underestimated the total sediment flux entering the basin by not resolving high frequency fluctuations in the suspended sediment concentration. The present data set cannot resolve fluctuations having periodicities less than 40 minutes. If rapid fluctuations in sediment concentration were positively correlated with flood velocity fluctuations, then the actual suspended sediment flux would be greater. Unfortunately, without more rapid sampling, the question of aliasing of the suspended sediment flux estimates could not be resolved. For the present study, aliasing was assumed to be negligible.

Total Dynamic Head

Jenkins et al., (1983) found that the flow of the St Johns River past the entrance to Mayport turning basin causes the water level in the basin to be lower than the water level in the river during ebb river flow and higher during flood river flow. The physical processes which cause the water level differences are not well understood, however, the draw down of the basin is thought to be caused by an entrainment process at the river/entrance channel shear zone. In contrast, the super elevation of the basin during flood river flow is thought to reflect the dynamic head of the river.

As a result of the difference in water levels between the basin and the river, the total dynamic head which is available to produce a flow in the proposed canal is composed of two terms: the water level difference, and the velocity head of the river. Jenkins et al., (1983) measured both of these quantities for a period of several days, however, the location of these measurements was at the end of the carrier-berth peninsula, as opposed to the site of the proposed canal. Moreover, Jenkins, et al., (1983) analyzed their measurements in terms of short period variations (tens of seconds) in the water level differences as opposed to longer period variations (an hour or longer), which are of interest in the present study.

Because of these differences, the present study sought to: (1) obtain new measurements of water level differences at a location nearer to the site of the proposed canal; and (2) re-analyze the water level measurements of Jenkins et al., (1983) in terms of longer period variations. Unfortunately, local Radar signals interfered with the pressure sensor data recorder causing a complete loss of all water level measurements. As a result, only the Jenkins et al. data set was available for analysis. However, theory suggests that the maximum difference in the water level differences measured at the two sites should be less than 1 cm.

Figure 11 shows a plot of the basin water level, the river water level, and the river velocity (positive = flood or west) as a function of time for most of a tidal cycle on 17 Feb 1983. The figure shows that

at low tide, the river velocity is at maximum ebb while at high tide the river velocity is at maximum flood. These currents produce a sea level inequality between the river and the basin, with the basin being lower than the river at low tide and higher than the river at high tide. Although measurements of water elevations were not obtained in the present study, measurements of river velocities were obtained (see Figure 12). These velocities show a close correlation with the tide, substantiating the data measured by Jenkins et al., (1983).

Figure 13 shows a plot of the difference in water level elevation between the basin and the river for the same data as shown in Figure 11. It is apparent that the water level inequality closely follows the tide, with the basin being approximately 5 cm lower than the river at low tide (approximately 1700 hours), and 10 cm higher than the river at high tide (approximately 2300 hours). The data shows that during the time in which it would be most beneficial for the canal to be open (during the 6 hours between low and high tide), the water level of the basin is lower than the level of the river only during the first 3 hours. After 2000 hours, the basin is higher than the river. This would cause the canal flow to be out of the basin, drawing more sediment-laden water into the entrance channel and increasing the sedimentation rate in the basin. Clearly, a gate is needed for the canal to function as intended.

A canal simulation model, which will be discussed shortly, requires estimates of the water level inequality and the near-bank river velocity as a function of time. An examination of these variables (see Figures 11 and 13) showed them to be closely correlated with the tide. As a result, the following regression equations were obtained.

$$\Delta\eta = 8.4 \times 10^{-4} \eta_r^2 + 0.015 \eta_r - 4.1 \quad (5)$$

and

$$U_r = 0.662 \eta_r - 41.1 \quad (6)$$

where $\Delta\eta$ is the sea level inequality (basin-river) in cm, η_r is the tide in the river in cm MLLW, and U_r is the near-bank river velocity (cm/sec,

positive on flood). Figures 14 and 15 show a plot of $\Delta\eta$ and U_r versus η_r along with their respective regression equations.

Fortunately, the tidal conditions present during the field study by Jenkins et al., (1983) were nearly identical to the present study. In the former case (17 Feb 1983) high and low tide elevations were 1.22 and -0.09 meters MLLW respectively, versus 1.34 and -0.06 meters MLLW in the present study (1 Apr 1984). As a result, the sea level inequality and river velocity estimates generated from Equations 5 and 6 are probably representative of conditions occurring on 1 Apr 1984.

In-Situ Bulk Densities

The suspended sediment fluxes discussed above are expressed in terms of the dry weight flux of suspended sediment per unit of time. In order to compare the estimated suspended sediment fluxes with the average annual sedimentation rate in the basin (approximately 448,000 m³/yr), it was necessary to know the density of the predredged sediment deposit. During the field study, core samples were taken at five different sites within the turning basin. These were analyzed for wet bulk density, and the equivalent dry weight densities were computed. The average wet bulk density was found to be 1,085 kg/m³ while the an equivalent dry bulk density was found to be 94.1 kg/m³. The net shoaling rate can be computed from the net dry sediment flux by dividing by the in situ dry bulk density, i.e., 1 kg of dry sediment is equivalent to 0.011 m³ of sedimentation.

SIMULATION MODEL

The key to estimating the efficiency of the proposed canal or jetty in reducing sedimentation in Mayport turning basin is to understand their effect on the sediment flux into the turning basin. The method used to predict these effects was to construct a simple box model of the basin, which accounted for all of the suspended sediment flux passing into or out of the basin. This flux was predicted over a complete tidal

cycle using the present data set. Although the conditions measured on 1 Apr 1984 were probably not representative of average annual conditions, it was assumed that the relative effect of these structures on the sedimentation rate would remain constant throughout the year.

Figure 16 shows a schematic diagram of the box model used in the present analysis. The box model consisted of: a basin with plan area A_p ; an entrance channel with cross-sectional area A_e and length L_e , the latter of which can vary depending on the length of any proposed jetty; and, a canal with cross-sectional area A_c and length L_c . The overall volume flux (flow rate) of water passing into and out of the basin was assumed to be controlled by the tide, with the sum of the flows passing through the entrance channel and the canal equal to the overall undisturbed tidal flux.

The water level in the river was assumed to be equal to the predicted tide based on the tide table data for 1 Apr 1984 (see Figure 17). The water level in the basin was assumed to be equal to the river level plus the sea level inequality predicted by Equation 5. Near-bank river velocities were predicted by Equation 6 using the tidal elevation of the river. The model allowed the cross-sectional area of the canal and the length of the entrance channel jetty to vary as specified.

Considering the volume flux of water into the basin, continuity requires that

$$Q_c + Q_e = Q_{eo} \quad (7)$$

where: Q_c = canal flow rate into the basin

Q_e = entrance channel flow rate into the basin

Q_{eo} = flow rate which normally passes through the entrance channel in the absence of a canal

Q_{eo} was estimated from Equation 1 in conjunction with the measured velocity data.

The canal flow rate (m^3/sec) was predicted using the following open channel flow equation:

$$Q_c = \frac{1.00}{n} A_c R_c^{2/3} \sqrt{\frac{\text{Thd}}{L_c}} \quad (8)$$

where: R_c = hydraulic radius of the canal, meters

Thd = total dynamic head between the river and the basin, meters

n = roughness coefficient (approximately 0.012).

L_c = canal length, meters

Noting that with the exception of Thd , all of the parameters in Equation 8 are constant, Equation 8 was rewritten as:

$$Q_c = K_{\text{prime}} \sqrt{\text{Thd}} \quad (9)$$

where

$$K_{\text{prime}} = \frac{1.00}{n} \frac{A_c R_c^{2/3}}{L_c^{1/2}} \quad (10)$$

During ebb river flow, Thd can be expressed as

$$\text{Thd} = \Delta\eta + \frac{U_r^2}{2g} \quad (11)$$

Where $\Delta\eta$ and U_r can be predicted from Equations 5 and 6.

The present study measured the suspended sediment concentration in both the river and the basin entrance channel. In principle, these concentrations can be used to predict the suspended sediment fluxes passing through the canal and entrance channel once the respective flow rates were known. One complication in this approach, however, is that the sediment entering the basin through the entrance channel takes a finite period of time to pass the length of the entrance channel. The suspended sediment concentration measured at the entrance to the basin is a function of both the time history of the channel velocity and the time history of the suspended sediment concentration at the interface

between the river and entrance channel. Because the entrance channel velocity will vary with canal flow rate, it was found to be simpler to work with the estimated suspended sediment concentration at the river/channel interface and to predict the resulting time lag.

In the present study, the suspended sediment concentration at the river/channel interface was assumed to be equal to the concentration measured along the banks of the river. A visual comparison between the river and entrance channel suspended sediment concentration measurements suggested that this was a reasonable approximation since the peak values were approximately equal. A more accurate approach would have been to use the actual suspended sediment concentration at the interface, however, this was not measured. For the canal, the suspended sediment concentration was assumed to be equal to the suspended sediment concentration in the river with a zero time lag.

Considering the entrance channel flow, the length of time (lag time), Δt , needed for a suspended sediment particle to travel the length of the entrance channel, L_e , was estimated from the following equation:

$$\frac{1}{A_e} \int_{t-\Delta t}^t Q_e dt = L_e \quad (12)$$

At first glance, the length of the entrance channel, L_e , would appear to be equal to the length of the jetty. Lacking a jetty, this length would be zero, however, the measured suspended sediment concentration data indicated a time lag close to 1.67 hours. Based on Equation 13, this time lag suggested that the entrance channel has a "natural" length of approximately 100 meters. Apparently, the shoal area which projects out from the end of the carrier-berth peninsula acts to separate the entrance channel from the river. In any event, L_e was assumed to be equal to the jetty length plus 100 meters throughout the analysis.

Utilizing Equations 4 and 7, the sediment flux into the basin can be expressed as:

$$SF = Q_c(C_r - C_e) + Q_{eo} C_e \quad (13)$$

where: C_r = suspended sediment concentration in the river

C_e = suspended sediment concentration in the inner reaches of the entrance channel

Based on the above discussion, during flood tide when the basin is filling, the suspended sediment concentration entering the basin from the entrance channel was computed as

$$C_e = C_r \Big|_{t = t - \Delta t} \quad (14)$$

During ebb tide, when the basin is emptying, C_e was assumed to have a constant value of 0.01 gm/liter. The value was selected rather arbitrarily to reflect a general background concentration level during late ebb tidal flow out of the basin (see Figure 5). A better estimate would reflect the time history of sediment influx into the basin minus a percentage due to deposition; however, this was judged to be too complex an approach for the present model.

The objective of the canal is to reduce the net flux of suspended sediment into the basin. To accomplish this, it is desirable to operate the canal only during flood tide when the basin is filling. During the roughly 6 hour period between low tide and high tide, however, the basin is lower than the river only during the first 3 hours or so. After that, the basin becomes higher than the river. If the canal were open during the latter half of the filling cycle, the canal flow would be out of the basin, causing additional flow to enter the basin from the entrance channel. The latter would carry additional sediment into the basin, causing increased shoaling. Obviously, it would be better for the canal to be closed at this time.

When the basin is emptying (between high and low tide), it is desirable to force all of the flow out through the entrance channel. This will help to minimize shoaling in the channel. If suspended sediment

concentrations were sufficiently low within the river, it would be beneficial to open the canal during the 3-hour period of time preceding low tide. This would serve to feed water into the basin, increasing ebb channel flows, and further scouring sediment from the entrance channel. The data measured in the present study, however, suggested that suspended sediment concentrations in the river were too high relative to the basin for this to have a net positive effect.

The above arguments suggest, that the canal requires a gate which can be synchronized with the tide. In fact, it will be shown that the precise time at which the gate is opened and closed in relationship to the tide, has a profound effect on the efficiency of the canal.

Equations 1, 9, 12, 13, and 14 completely describe the sediment flux as a function of time. The final step was to integrate the sediment flux (Equation 13) over a complete tidal cycle to compute the net sediment flux into the basin.

Because of the approximate nature of the box model and the fact that the conditions measured on 1 Apr 1984 were probably not representative of yearly "average" conditions, the relative reduction (or increase) in the net sediment flux into the basin was estimated instead of the absolute magnitude. In addition, the present model only predicts the shoaling which takes place in the turning basin. Bathymetric surveys have shown that 85% (381,000 m³/yr) of the sediment dredged at Mayport comes from the turning basin, while 15% (67,000 m³/yr) comes from the entrance channel. Assuming that the latter amount remains unchanged by the presence of a canal or a jetty (a rather questionable assumption made necessary by a lack of better information), then the relative shoaling rate, RSR, can be expressed as

$$RSR = \frac{(381,000 \times NSF + 67,000)}{448,000} \quad (15)$$

where the net shoaling factor, NSF is defined as

$$NSF = \text{net sed flux/net sed flux (base-conditions)} \quad (16)$$

Finally, the efficiency of the canal or jetty is equal to 1 - RSR.

The canal/jetty simulation model was used to evaluate the performance of a number of different-sized canals and jetties, both individually and in conjunction with each other. In simulating the effects of the canal, it was assumed that the canal incorporated a gate which could be opened and closed as desired.

Initially, no assumptions were made concerning the geometry of the canal: its length, its height, or its width. Instead, canals with different capacities were evaluated in terms of K_{prime} (see Equation 10). Values of K_{prime} were varied between 0 (no canal) and $500 \text{ m}^{5/2}/\text{sec}$ during simulation. For purposes of evaluating the proposed canal, it was assumed that the canal had a rectangular cross-section, a water depth of 3 meters (10 feet), and a length of either 200 meters (656 feet) or 75 meters (246 feet). The former value is the approximate length of a canal located in the northwest corner of the basin canal, while the latter is the length of a canal located at an alternative site near the end of the carrier-berth peninsula. The advantage of this latter site would be a shorter length canal with a smaller cross-section, due to the increased slope of the water in the canal. No attempt was made to simulate the change in cross-sectional area that would occur as a function of the tide, thus a conservative design approach would be to assume that the elevation of the base of the canal is -3 meters (-10 feet) MLLW.

In operating the simulation model, it soon became clear that it would be advantageous to open the canal only during periods of low suspended sediment concentration in the river. In practical terms, this meant delaying opening the gate for a short time following low tide and closing the gate while the sea level inequality was still positive. Figure 18 shows a plot of the suspended sediment concentration in the river as a function of time for 1 Apr 1984. The data shows that the sediment concentration reached a peak of around 0.05 gm/liter about an hour before low tide. The sediment concentration remained near this peak until low tide (1400 hours) at which point it began to decrease rapidly with time. A minimum concentration was reached around 1500 hours with the concentration remaining low until 1600 hours at which point it began to rapidly increase again.

The objective of opening the canal gate only when the sediment concentration is low is to reduce the amount of sediment that is introduced into the basin via the canal. Several different threshold values were tested in the model including: no threshold, 0.025, 0.020, and 0.015 gm/liter. Smaller threshold values indicate a shorter duty cycle time for the canal. Duty cycles corresponding to the above threshold values were: 4.33, 2.67, 2.0, and 1.17 hours respectively.

Figure 19 shows a plot of the relative shoaling rate versus K_{prime} for the case of no jetty. Each curve corresponds to a different threshold value of sediment concentration. The data in Figure 19 suggests that the optimum efficiency is obtained with a canal having a K_{prime} equal to approximately $450 \text{ m}^{5/2}/\text{sec}$ and a sediment concentration threshold value of 0.02 gm/liter. For these conditions, the predicted efficiency of the canal was approximately 60%.

Figure 19 also shows that for the case of no threshold (the canal is opened at low tide and left open for 4.33 hours), a canal with a K_{prime} of $450 \text{ m}^{5/2}/\text{sec}$ would increase the relative shoaling rate by approximately 300%. Alternatively, if the suspended sediment concentration of the surface river water which enters the canal was assumed to have a low constant value of 0.01 gm/liter (an assumption suggested in part by data from Van Dorn (1979)), the canal efficiency increases to 98%. Obviously, the canal's operation is very sensitive to the magnitude of the suspended sediment concentration in the river (relative to its value at the river/entrance channel interface) its variability with time, and its phase relationship with respect to the tide. Considering the limited data base from which to simulate the canal's operation, the sensitivity of the canal to data uncertainties translates into a significant degree of risk. This risk can be reduced by increasing the size and quality of the available data base.

Figure 20 shows a plot of K_{prime} versus canal width for a 75-meter long canal and a 200-meter long canal. The latter canal, which is currently proposed, will require a width of 15.5 meters (51 feet) for optimum operation. The corresponding width for the shorter alternative canal is 10.5 meters (34 feet). Both canals assume a water depth of

3 meters (10 feet). Obviously, the actual canal depth will have to be deeper to accommodate any tidal variation. The elevation of the base of the canal should be no higher than -3 meters MLLW.

The flow rate in the canal will vary as a function of time because of the variation in the total dynamic head. The latter, and thus the canal flow rate, is a maximum at low tide and decreases to zero approximately 3 hours later. For the recommended canal, the peak flow rate is $92 \text{ m}^3/\text{sec}$ (1,400,000 gpm). The corresponding head driving the flow is 4.2 cm. Note that the shorter canal can have a smaller cross-section because the slope of the water surface in the canal is greater.

Although the original intent of the study was to evaluate the effect of a venting canal on the rate of sedimentation in the turning basin at Mayport Naval Station, the simulation model was easily adaptable to evaluating the effects of a jetty extension.

Figure 21 shows a plot of the relative shoaling rate as a function of the jetty length for the case of no canal. The present model suggested that for jetty lengths of up to 300 meters, the effect was negligible. As the jetty length was increased to 400 meters and greater, however, the shoaling rate dropped dramatically. The predicted efficiency of a jetty 400 meters long was approximately 85%.

Another alternative which was evaluated was to combine a canal with a jetty. Figure 22 shows a plot of the relative shoaling rate as a function of K_{prime} for different jetty lengths. The suspended sediment concentration threshold value used to generate Figure 22 was 0.020 gm/liter. The figure shows that for a given-sized jetty, the relative shoaling rate decreases as the canal size is increased (increasing K_{prime}). Selecting the relative merits of a canal, a jetty, or a combination of the two, however, requires some consideration of the cost of the different options.

Although a complete economic analysis of the different alternatives was beyond the scope of this study, it was possible to look at the estimated first cost versus the degree of sedimentation prevention (based on cost estimates in U.S. Army Corps of Engineers (1979) and Jenkins et al, (1983). The cost of a jetty was estimated to be \$30K per meter of length, the cost of a 75-meter long canal was estimated to be

\$150K per meter of width and the cost of a 200-meter long canal was estimated to be \$250K per meter of width. The results of the cost analysis are shown in Figure 23, which assumes a 200-meter long canal with a suspended sediment concentration threshold value of 0.02 gm/liter.

Figure 23 shows that the lowest cost per cubic meter of sediment prevented (\$13.50/m³) occurred with a Kprime of 400 m^{5/2}/sec and no jetty. (The corresponding cost for a 75-meter long canal was \$5.50/m³.) Adding a jetty decreased the net sediment influx for a given-sized canal, however, the cost rose substantially. For example, a 200-meter long canal with a Kprime of 400 m^{5/2}/sec and a jetty length of 100 meters had a cost of \$30.00/m³.

DISCUSSION

The model used to simulate the effects of a canal or jetty is simplistic and should not be viewed as particularly accurate. One of the greatest uncertainties was in estimating the shoaling rate in the entrance channel. In the present model, the shoaling in the entrance channel was assumed to be constant. This would tend to increase the efficiency of the jetty relative to the canal. Another uncertainty is to what degree the present data set is representative of average annual conditions. Small departures from the measured conditions could have a significant effect on the predicted results. Unfortunately, the limited data base precluded a better assessment of the relative risks associated with building a canal (or a jetty).

Because of the simplicity of the model, the predicted shoaling reductions should be viewed as a relative measure of the effectiveness of the different options, and not as absolute values.

On the basis of cost alone, the canal appears to be the option of choice. The canal option, however, also involves the highest degree of uncertainty (risk). A brief discussion of the physical basis for each option helps to clarify this point. Physically, a jetty acts to increase the amount of time it takes for the sediment-rich river water at the river/entrance channel interface to travel from the interface into the

basin. While delaying the river water from reaching the basin, the basin is filling with the relatively sediment-poor water which was located in the entrance channel at the start of flood tide. If the jetty is long enough (400 meters or greater), then the river water never reaches the basin and most of the sedimentation is prevented. Of course some sedimentation would occur in the entrance channel, however, the present study assumed that subsequent ebb channel currents would resuspend all of this sediment.

A canal also increases the travel time for the sediment-rich river water to reach the basin. The travel time is increased because the flood velocities in the entrance channel are reduced by the canal flow. Unfortunately, the canal flow also brings some sediment into the basin; however, providing the sediment concentration at the surface of the river is less than that at the river/channel interface, a net reduction in the sediment flux is achieved. Alternatively, if, as in the present case, the sediment concentration in the river varies significantly with the phase of the tide, then a net reduction can still be achieved. The latter method, however, depends critically on the phase relationships between the tide, the river/interface sediment concentrations, and the sea level inequality. The sensitivity of the canal to variations in the relative sediment concentration levels is underscored by the fact that when the duty cycle of the canal gate was decreased by as little as 1 hour, the net sediment flux changed from a 300% increase to a 60% decrease.

The decision of whether to build a canal, to build a jetty, or to do nothing involves assessing the relative risk versus the relative potential economic payoff. Because of the limited data base and the sensitivity of the canal to environmental variability, there is presently a high degree of risk associated with building the canal. The canal, however, has the highest potential economic return. The jetty is less sensitive to environmental uncertainties, (i.e., less risky) however, it is an order of magnitude more costly. In terms of the seriousness of the shoaling problem at NAS Mayport, either solution may be preferable to doing nothing. A more in-depth assessment of the overall problem is warranted.

The principle reason for the high degree of uncertainty in the proposed venting canal is the limited environmental data base. At present there are approximately 3 days of data (most of it good) for the water level inequality between the river and the basin. There are approximately 10 to 12 hours of sediment concentration and sediment flux data that are closely correlated with the tide. Some of these data are ambiguous because of an uncertain time base (U1 and U3) and because of insufficient sampling rates (C1, C2, C3, C4). The greatest difficulty, however, is simply a lack of data on river and entrance channel sediment concentrations as a function of the tide.

The data gathered in the present study appear to be representative of relatively mild shoaling conditions. An important question is: how different are the conditions during periods of heavy shoaling? If the sediment concentrations in the river do not vary significantly with time, and if they are approximately the same magnitude as that at the interface, then the canal will fail to reduce sedimentation in the basin. On the other hand, if sediment concentrations are generally low at the surface of the river relative to the interface, the canal may function much better than expected. A larger body of data covering the sediment concentrations in the river and in the basin as a function of time is needed in order to resolve these uncertainties. If the canal is eventually built, this body of data will be of value in determining the proper duty cycle for the canal gate.

CONCLUSIONS AND RECOMMENDATIONS

1. The venting canal proposed for the northwest corner of the basin is too narrow, too shallow, and requires an automatic gate. Based on the results of this study, a canal in this location should have a width of 15.5 meters, a water depth of 3 meters, and a base depth of -3 meters MLLW. The canal, when fitted with an automatic gate, is expected to reduce the overall shoaling rate by 60%.

2. The effectiveness of the canal is particularly sensitive to the relative magnitudes of sediment concentrations in the river and at the river/channel interface. The phase relationships between these sediment concentrations, the sea level inequality, and the tide are also important. Small changes in these variables were found to have a significant effect on the estimated efficiency of the canal. Because of an insufficient environmental data base, there is a significant degree of uncertainty associated with the project. Additional concentration data should be gathered in order to reduce this uncertainty and to select an optimum duty cycle for the canal gate.

3. Consideration should be given to placing the canal near to the end of the carrier berth peninsula. This location would allow the canal length to be shortened to approximately 75 meters and the width narrowed to 10.5 meters. The cost of a canal in this location would be significantly less, with no reduction in the estimated efficiency.

4. A 400- to 500-meter long jetty, extending seaward from the carrier-berth peninsula, appears to present a lower risk than the venting canal. A jetty of this size would produce an estimated 85% reduction in the sedimentation rate. Unfortunately, the cost of a 600 meter long jetty has been estimated to be \$20M. Moreover, a jetty is not without risks, particularly with respect to the uncertainty in the shoaling rate which will occur in the entrance channel. Low cost methods of jetty construction should be investigated. If costs could be reduced by 50%, a jetty would become an attractive option.

5. Because of the model's simplistic treatment of the interfacial sediment concentrations during flood and the basin sediment concentrations during ebb, the projected benefits of the different shoaling reduction options should be viewed as only a relative measure of their effectiveness. Quantitative estimates of shoaling reductions will require a more detailed environmental measurement program, and a more sophisticated numerical model.

REFERENCES

U.S. Army Engineers Corps of Engineers. Mayport-Mill cove study, Army Engineers Waterways Experiment Station Technical Report no. HL-70-12, 1979, 104 pp.

S.A. Jenkins, D.L. Inman, and D.W. Skelley. The action of sea level inequalities upon sediment influx events at Mayport Naval Station, SIO Reference Series no. 83-19, 1983, 47 pp.

J. Hoffman. Investigations into deep-draft vessel berthing problems at selected U.S. Naval facilities, ONR and Naval Facilities Engineering Command, Contract Report no. 4914-801, 1980, 138 pp.

W.G. Van Dorn. Evaluation of Mayport-Mill cove model study, Naval Facilities Engineering Command Contract Report no. N00014-76-C-0631, 1979.

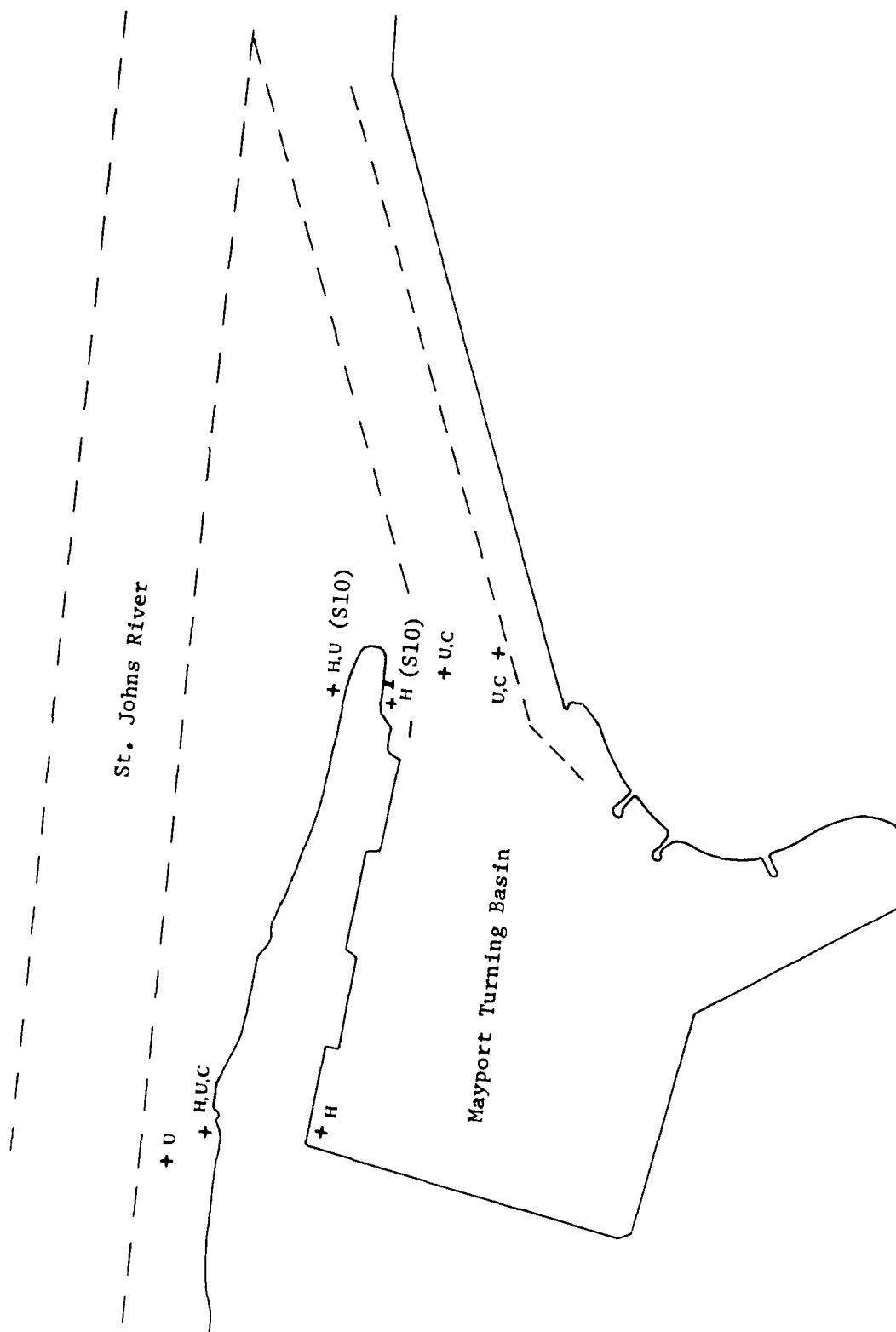


Figure 1. Plan view of Mayport turning basin showing the location of the field measurements. The symbols u , c , and h refer to velocity, sediment concentration, and pressure measurements. SIO refers to measurements made by Jenkins et al., (1983).

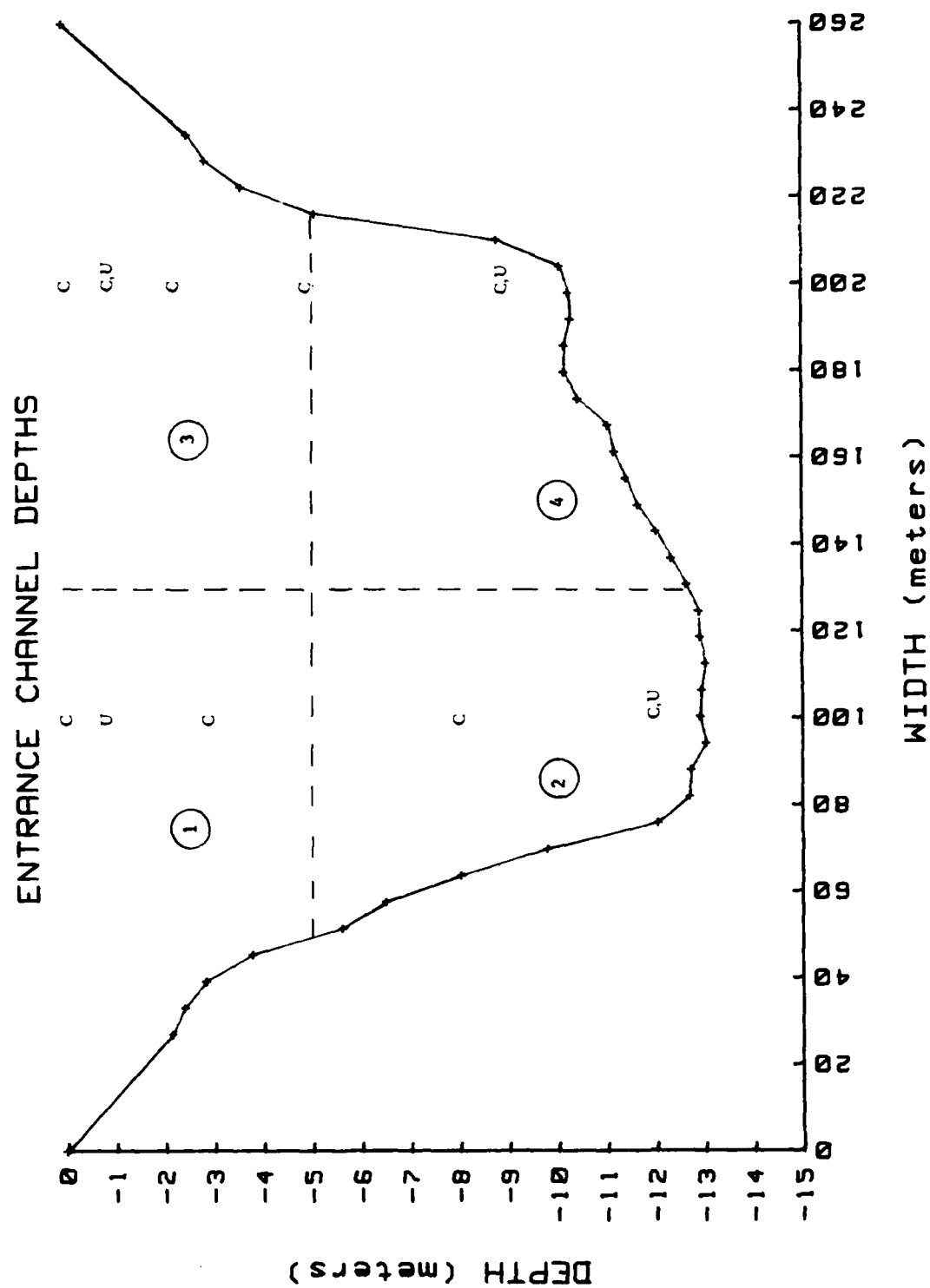


Figure 2. Entrance channel cross-section showing the location of the velocity (u) and sediment concentration measurements. The numbers 1-4 refer to sector areas which are used in estimating the entrance channel flux.

MAYPORT ENTRANCE 1 APR 84

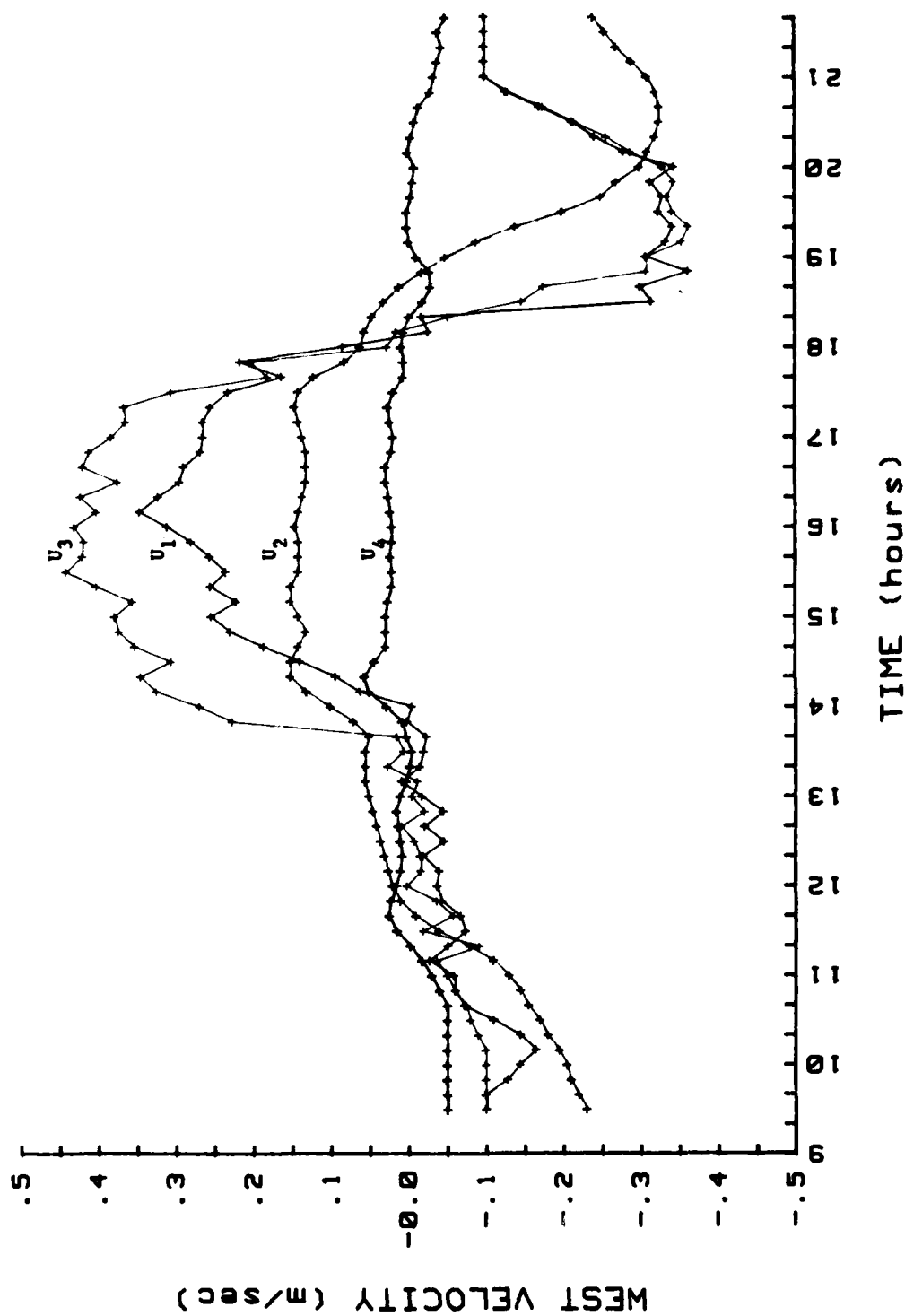


Figure 3. Measured surface (U_1 , U_3) and bottom (U_2 , U_4) velocities in the entrance channel to Mayport turning basin on 1 April 1984.

MAYPORT NORTH ENTRANCE

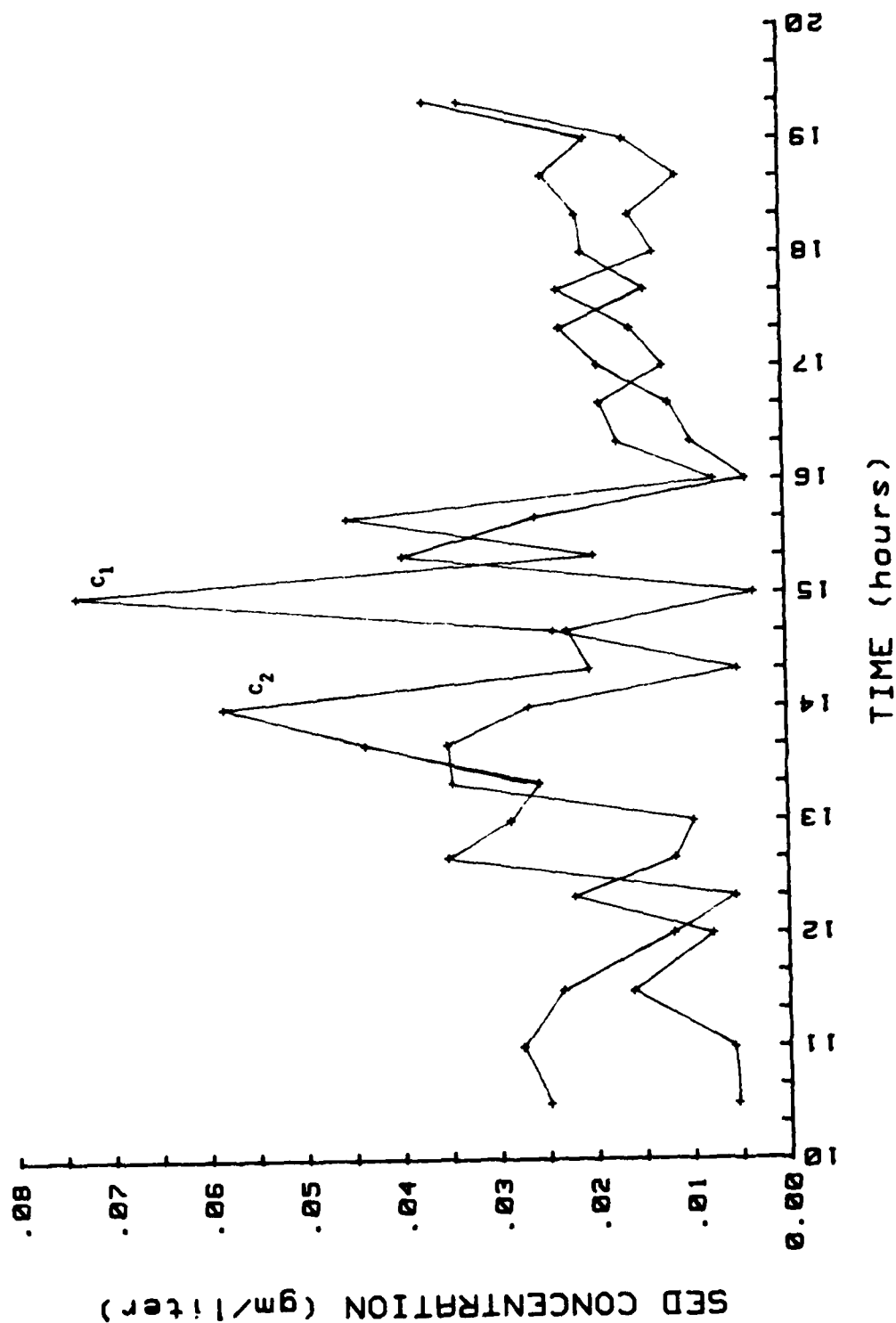


Figure 4. Measured surface (C₁) and bottom (C₂) sediment concentrations in the entrance channel to Mayport turning basin (north side) on 1 April 1984.

MAYPORT SOUTH ENTRANCE

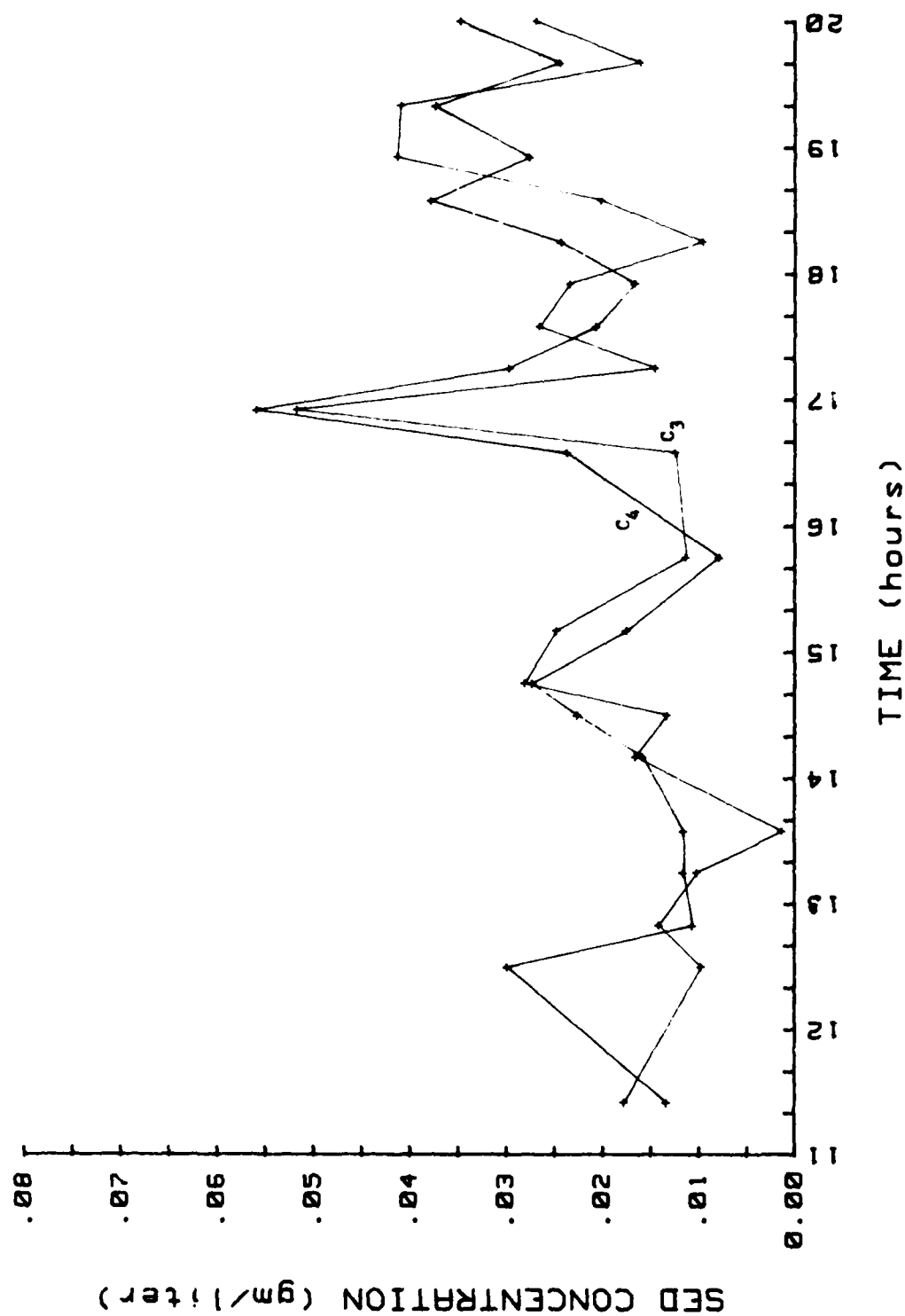


Figure 5. Measured surface (C3) and bottom (C4) sediment concentrations in the entrance channel to Mayport turning basin (south side) on 1 April 1984.

MAYPORT ENTRANCE 1 APR 84

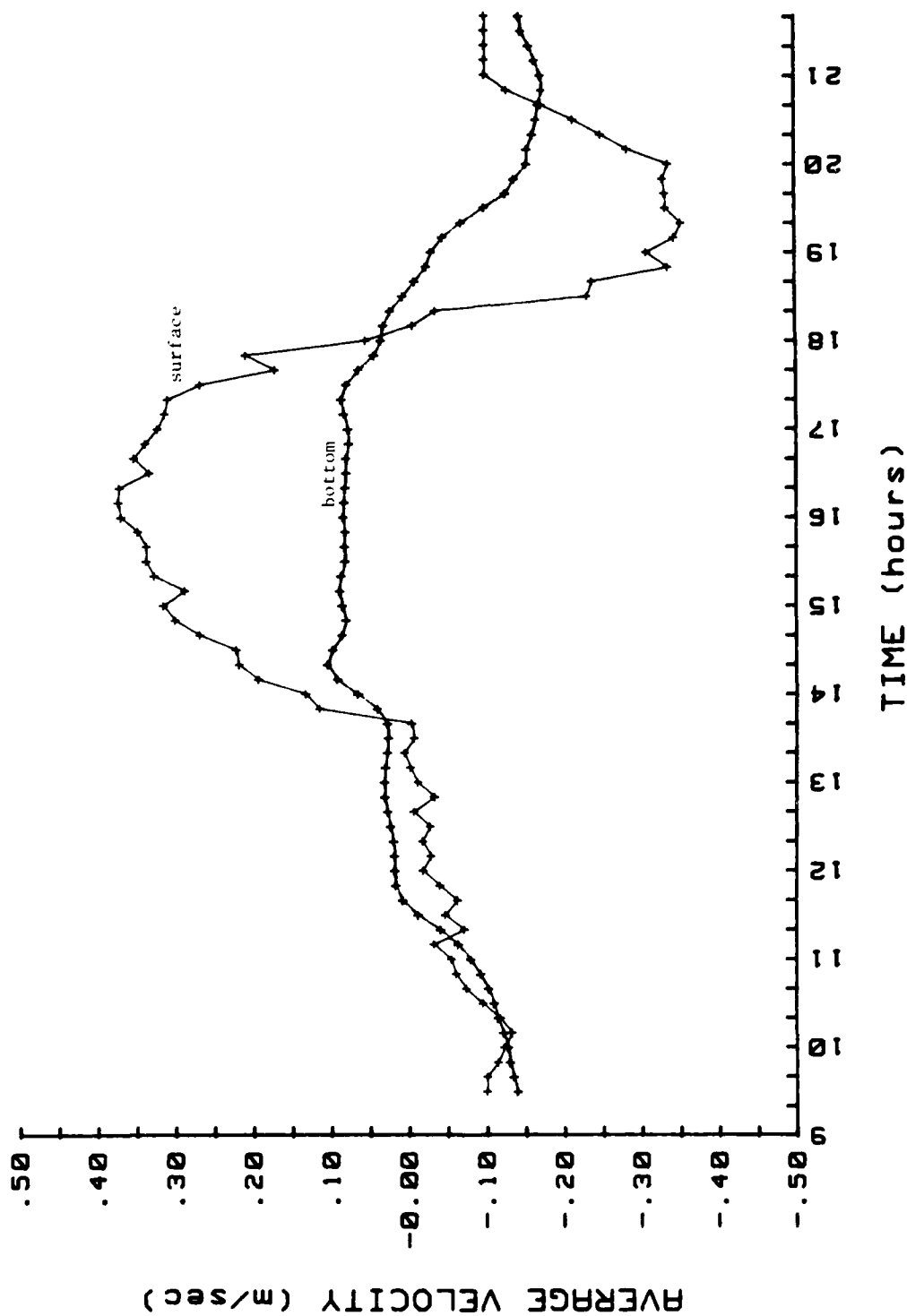


Figure 6. Spatially averaged surface and bottom currents in the entrance channel to Mayport turning basin on 1 April 1984.

MAYPORT ENTRANCE 1 APR 84

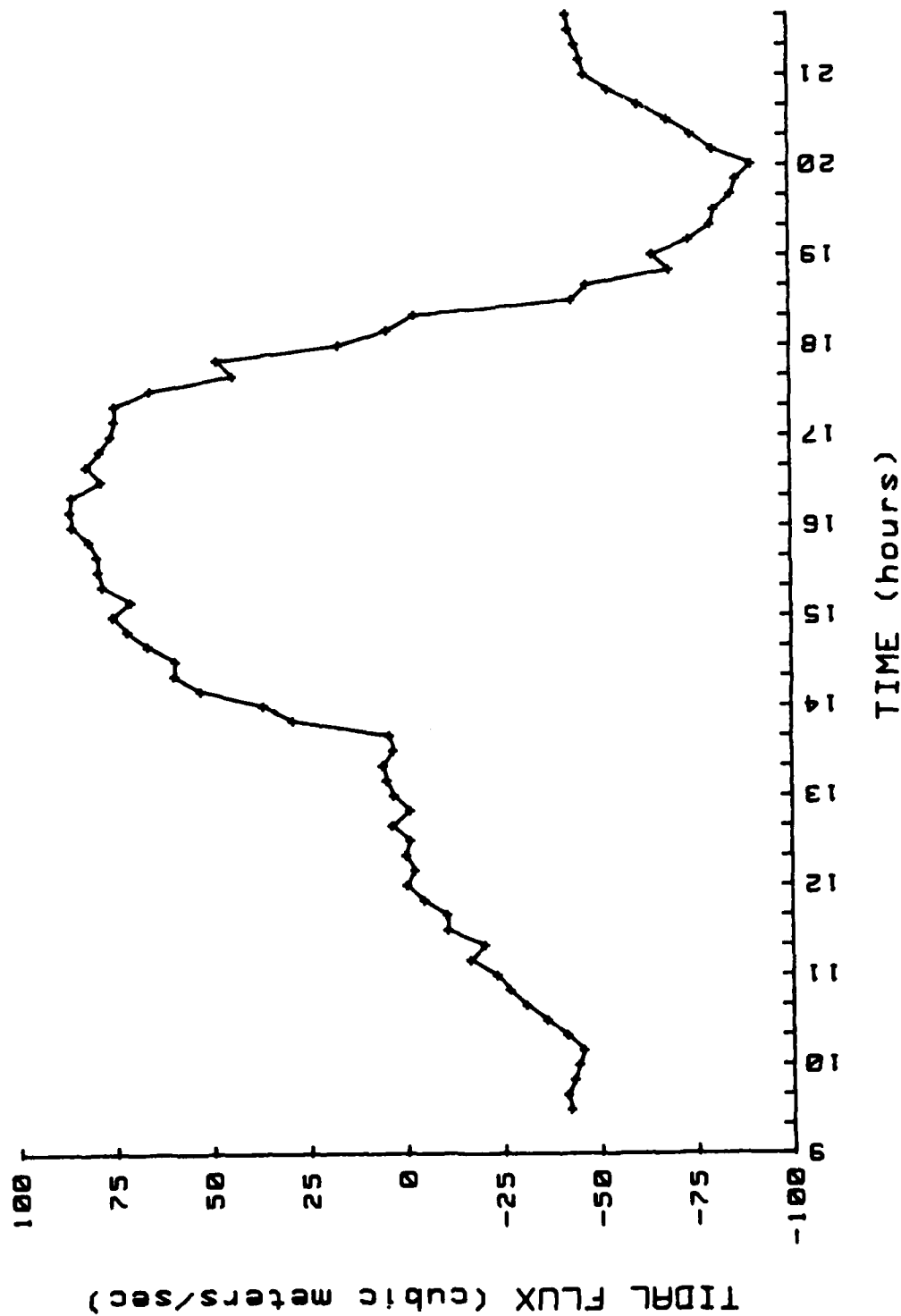


Figure 7. Estimated tidal volume flux (positive into basin) in the entrance channel to Mayport turning basin on 1 April 1984.

MAYPORT ENTRANCE 1 APR 84

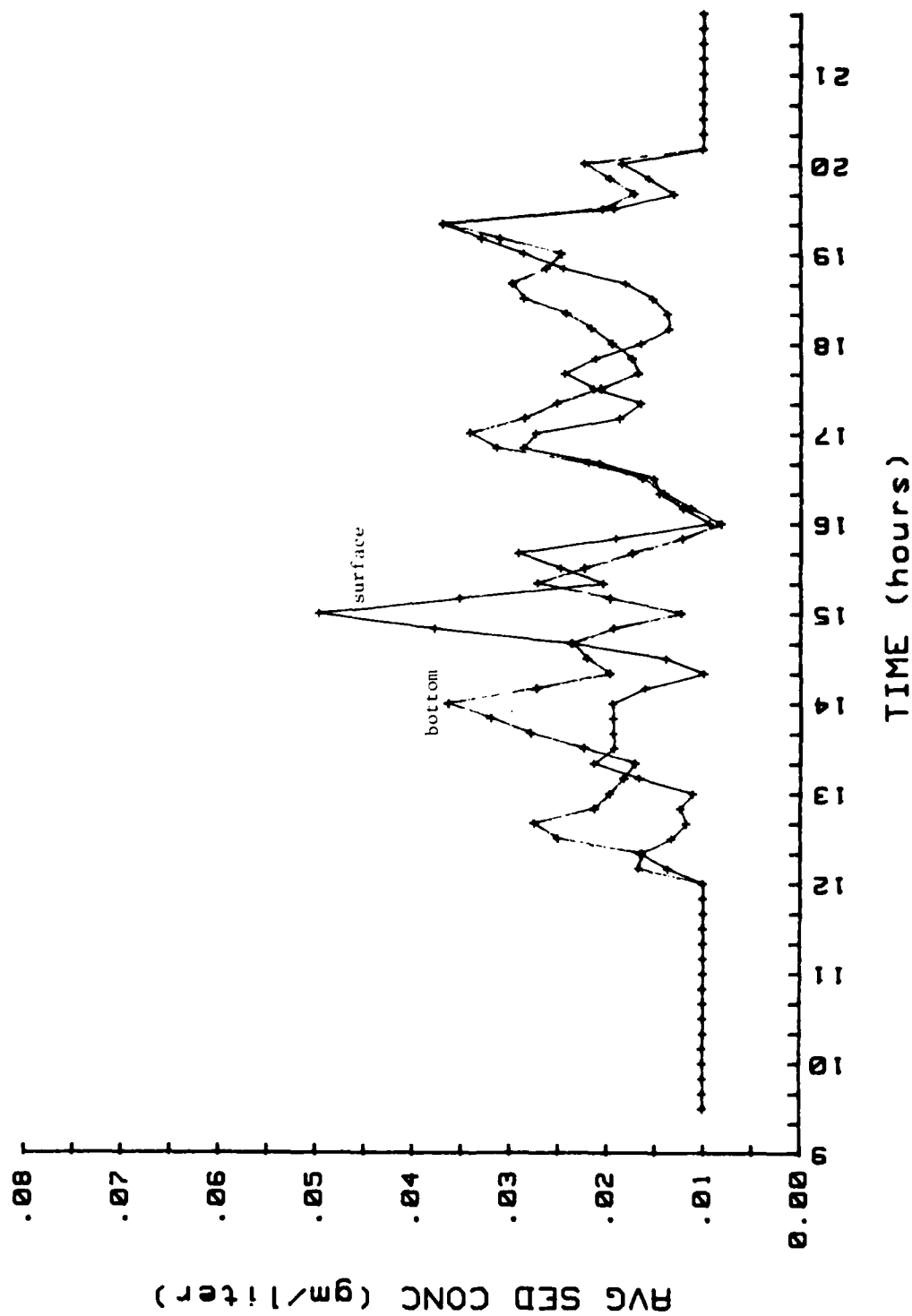


Figure 8. Spatially averaged surface and bottom sediment concentrations in the entrance channel to Mayport turning basin on 1 April 1984.

MAYPORT ENTRANCE 1 APR 84

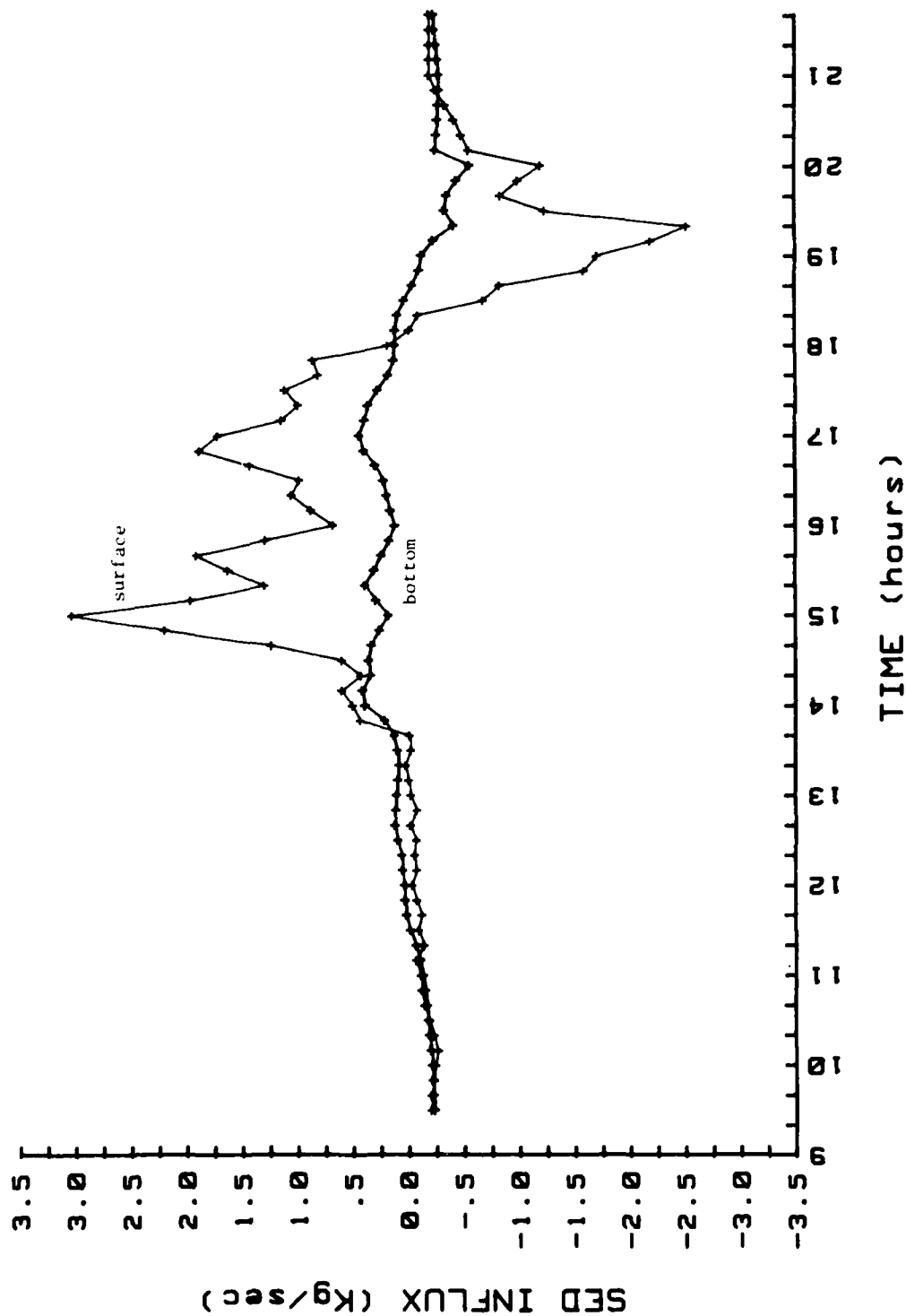


Figure 9. Estimated surface and bottom sediment fluxes (positive into basin) in the entrance channel to Mayport turning basin on 1 April 1984.

MAYPORT ENTRANCE 1 APR 84

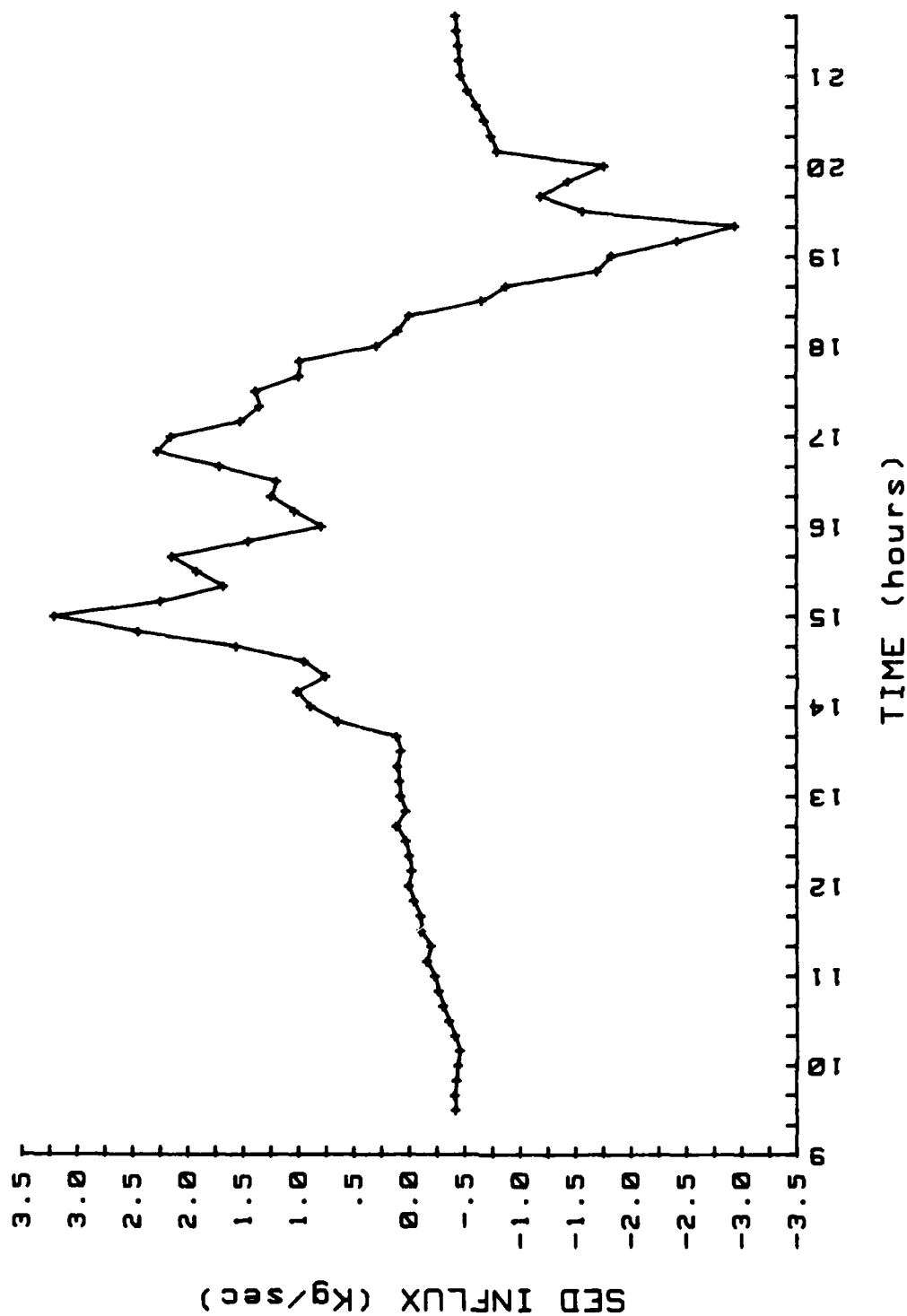


Figure 10. Estimated sediment flux (positive into basin) in the entrance channel to Mayport turning basin on 1 April 1984.

MAYPORT 17 FEB 83

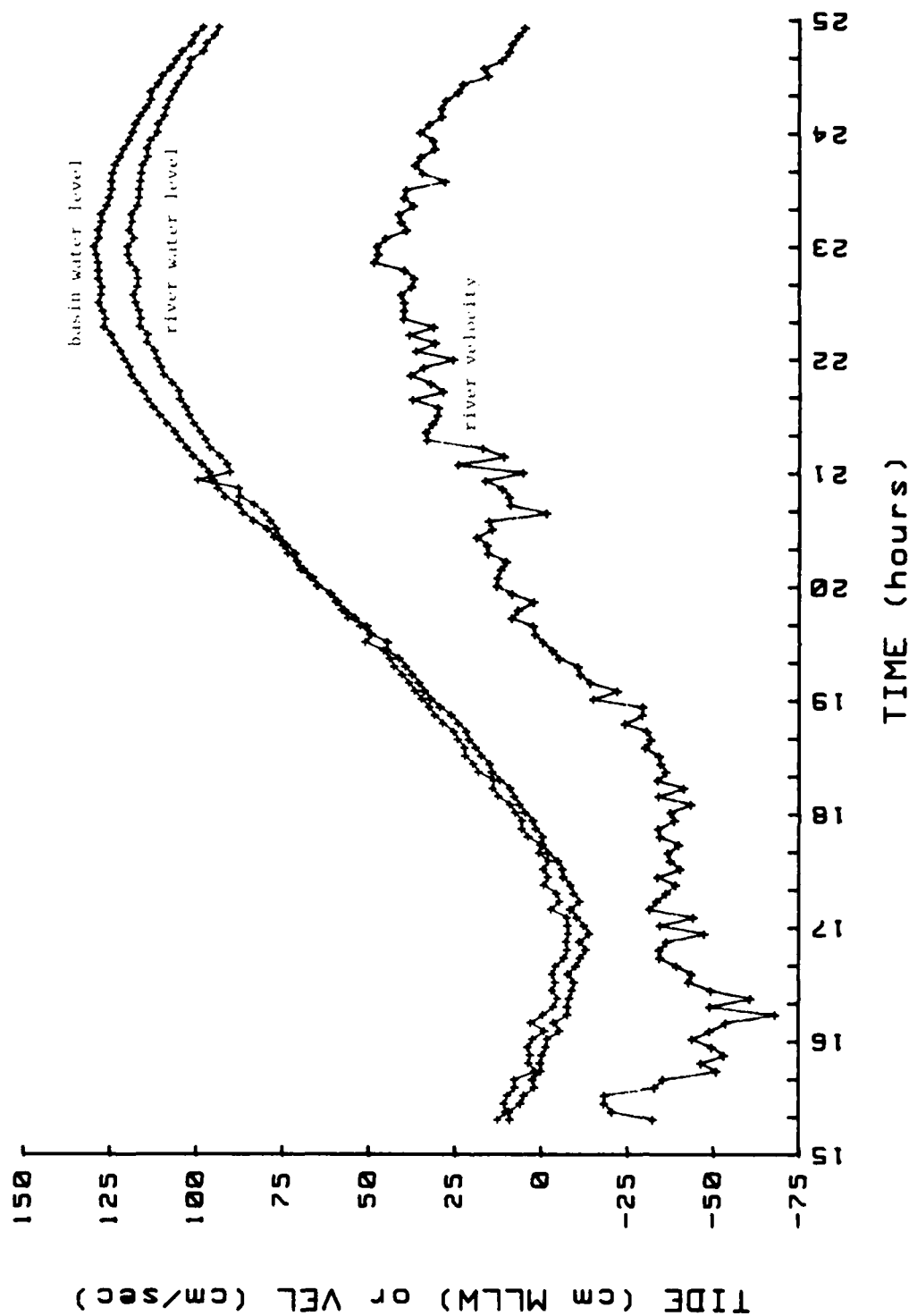


Figure 11. Measured water levels in the St Johns River and Mayport turning basin, and river velocities on 17 Feb 1983 (Jenkins et al., 1983).

ST. JOHNS RIVER 1 APR 84

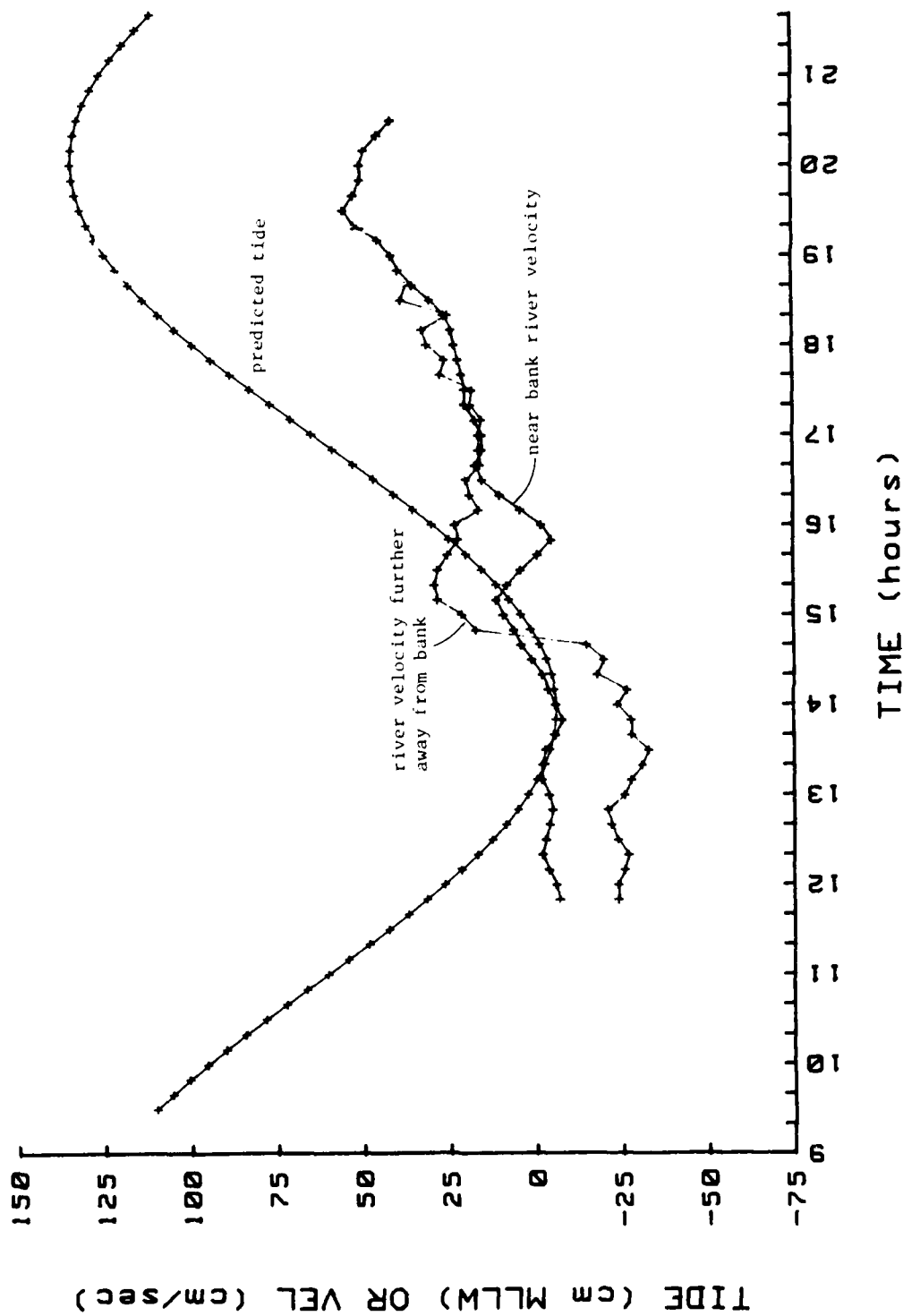


Figure 12. Predicted tide elevation and measured near-bank velocities in the St Johns River on 1 April 1984.

MAYPORT 17 FEB 83

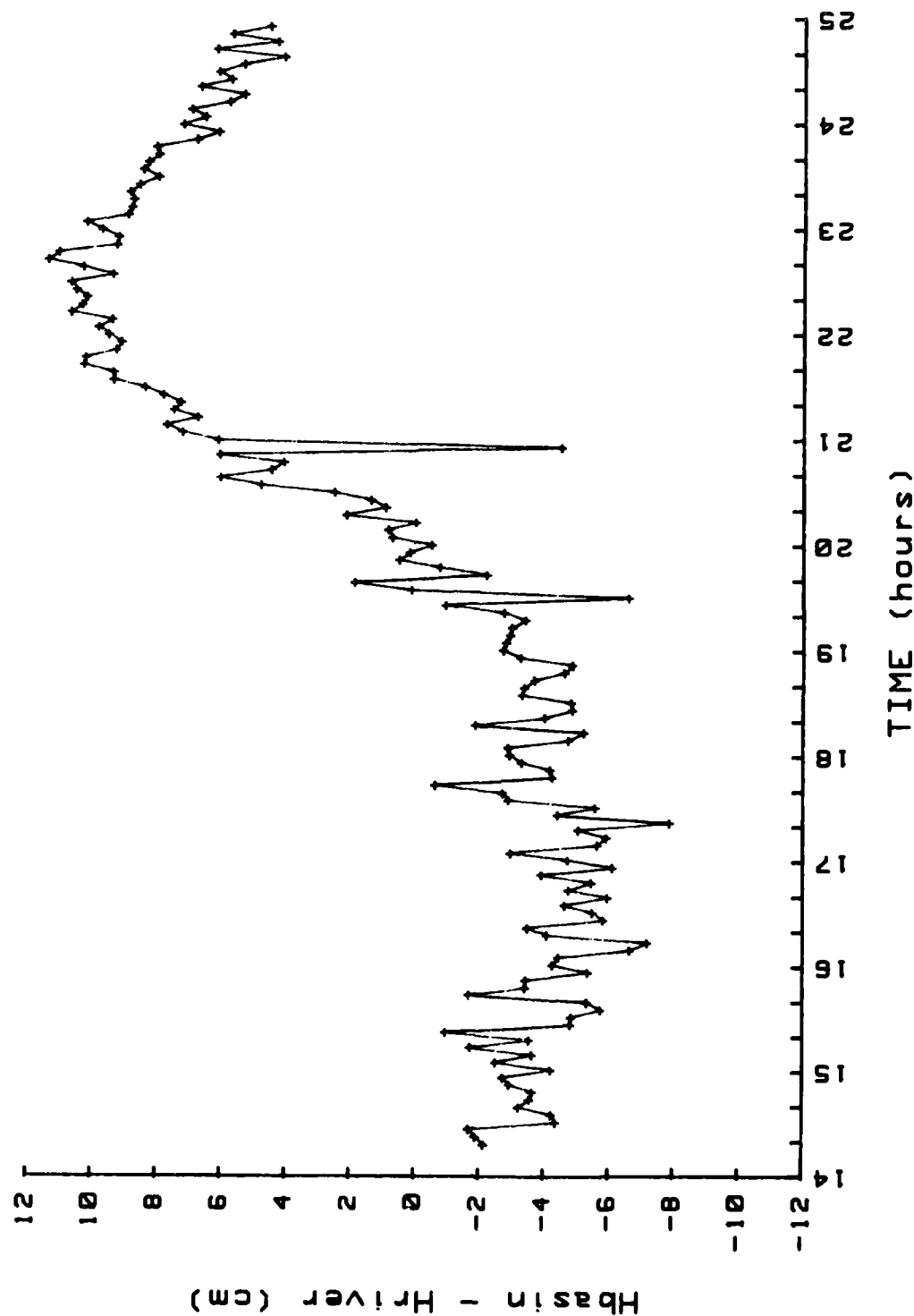


Figure 13. Measured sea level inequality (basin-river) between Mayport turning basin and the St Johns River on 17 Feb 1983 (Jenkins et al., 1983).

MAYPORT 17 FEB 83

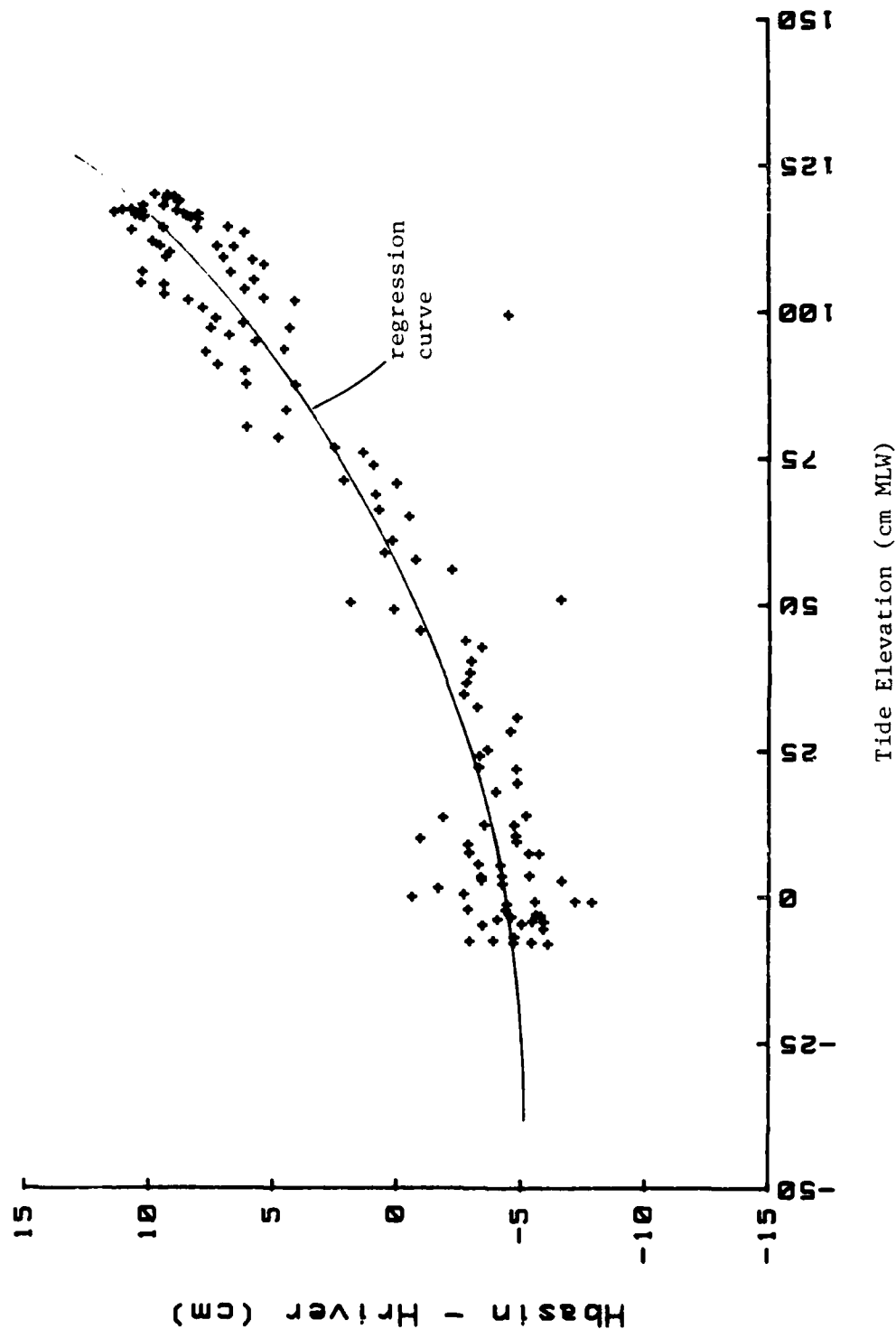


Figure 14. The inequality between the basin and river water levels (basin-river) was found to be correlated with the tide elevation in the St Johns River. The solid curve is a least squares fit to the measured data.

MAYPORT 17 FEB 83

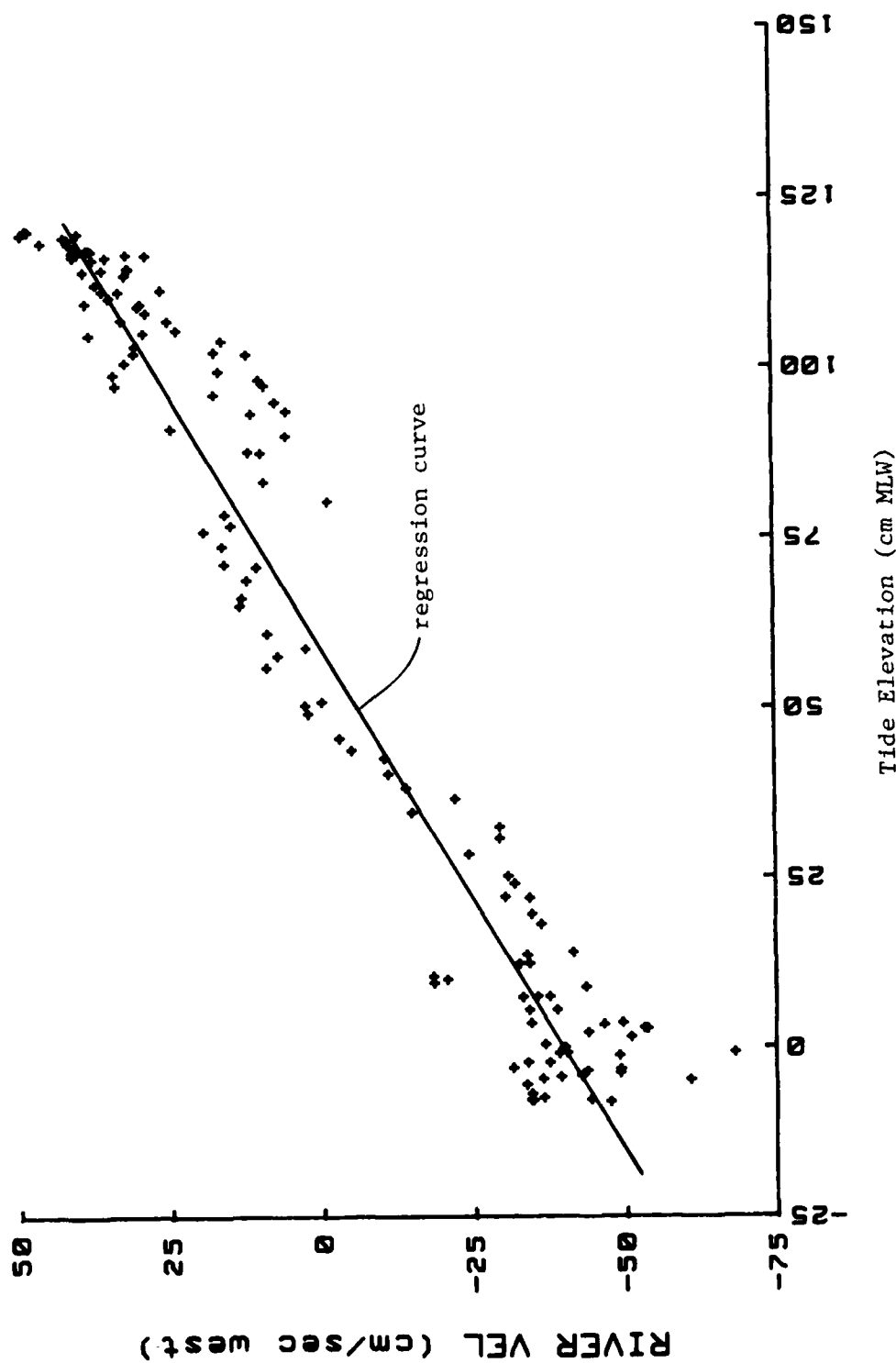


Figure 15. The near-bank velocity in the St Johns River was found to be correlated with the tide elevation in the river. The solid curve is a least squares fit to the data.

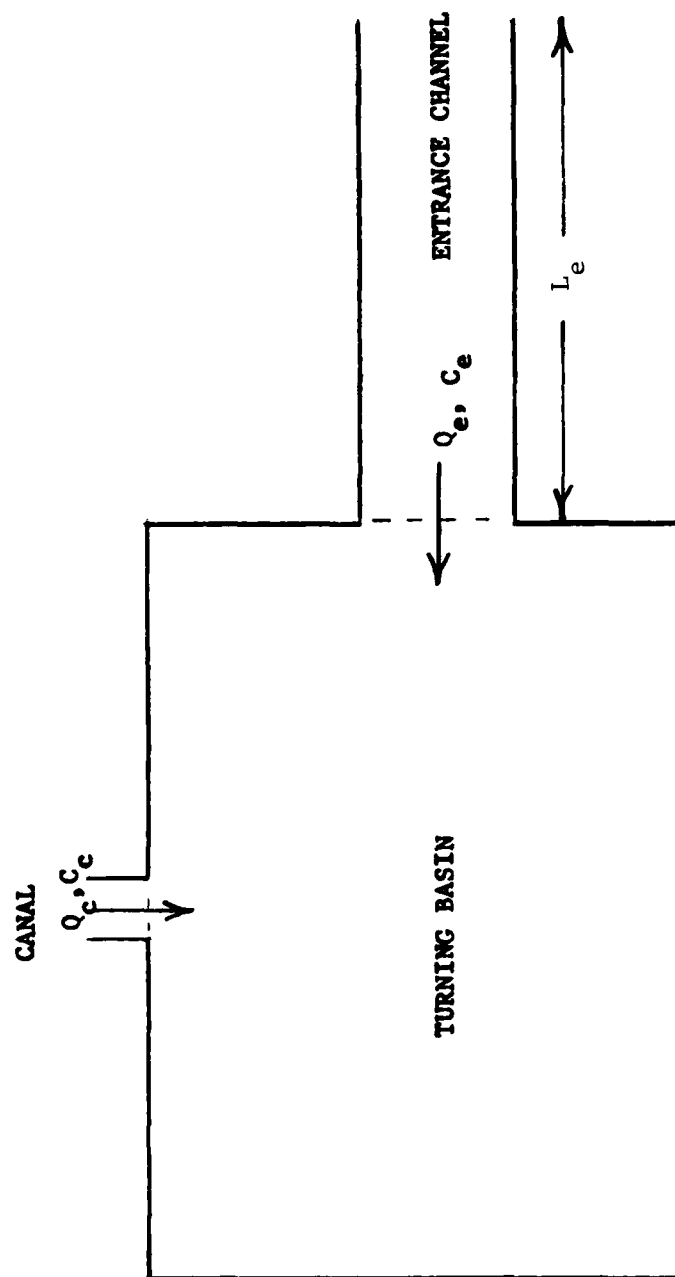


Figure 16. Schematic diagram of the box model used to simulate the effects of a venting canal and/or jetty extension on the rate of sedimentation at Mayport turning basin.

MAYPORT 1 APR 84

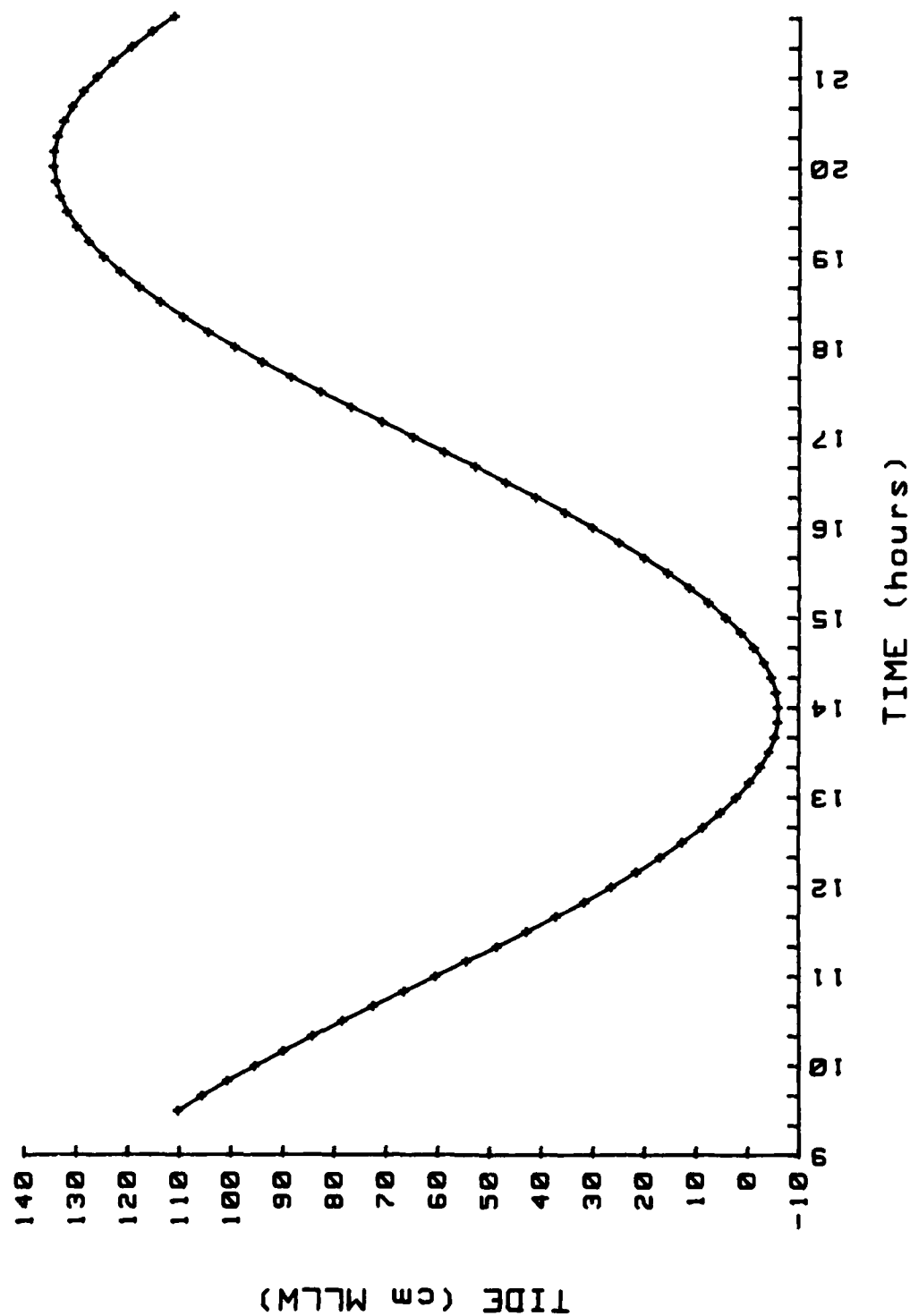


Figure 17. Predicted tide elevation in the St Johns River at Mayport Naval Station on 1 April 1984.

ST. JOHNS RIVER 1 APR 84

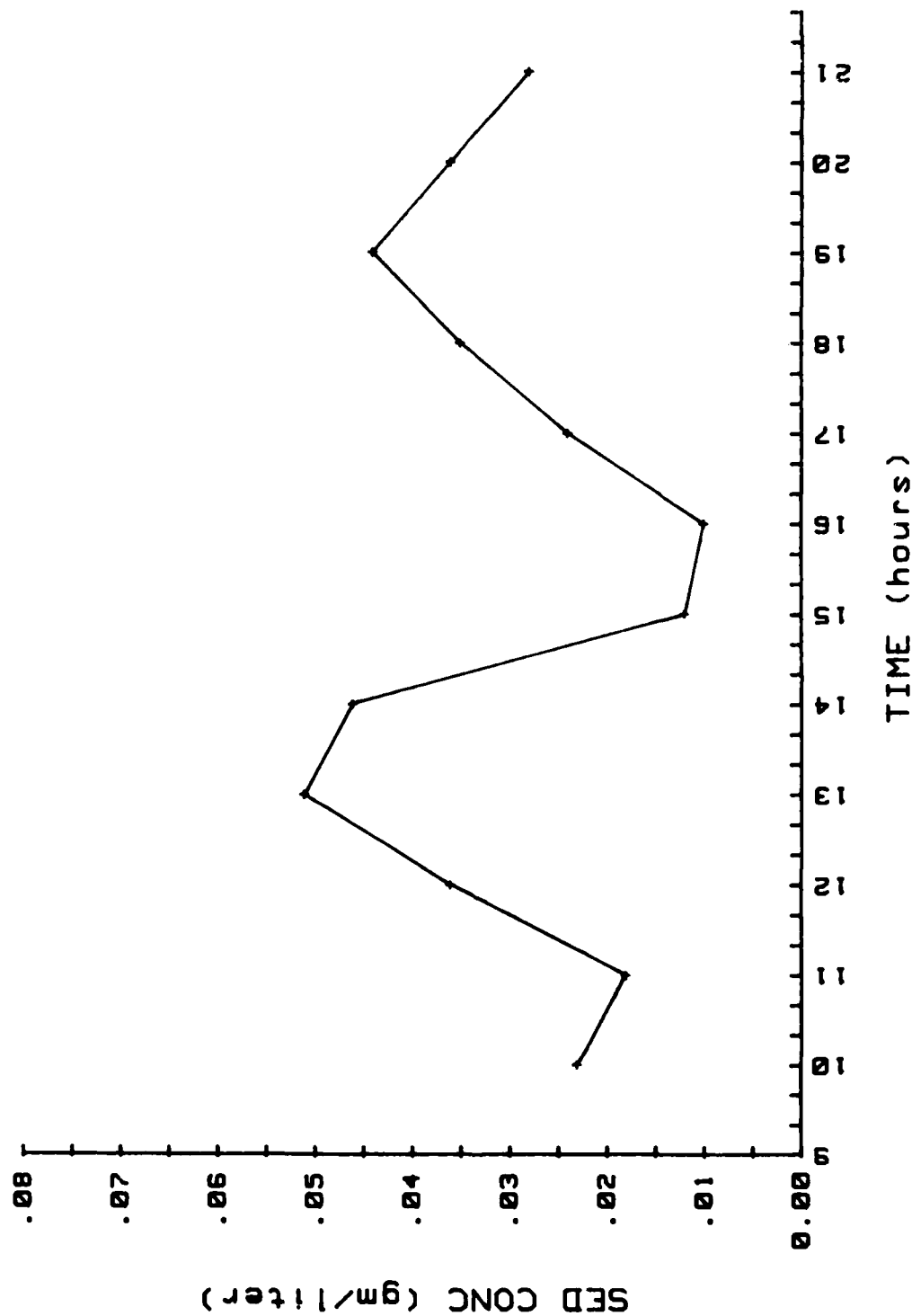


Figure 18. Measured near-bank surface sediment concentration in the St Johns River on 1 April 1984.

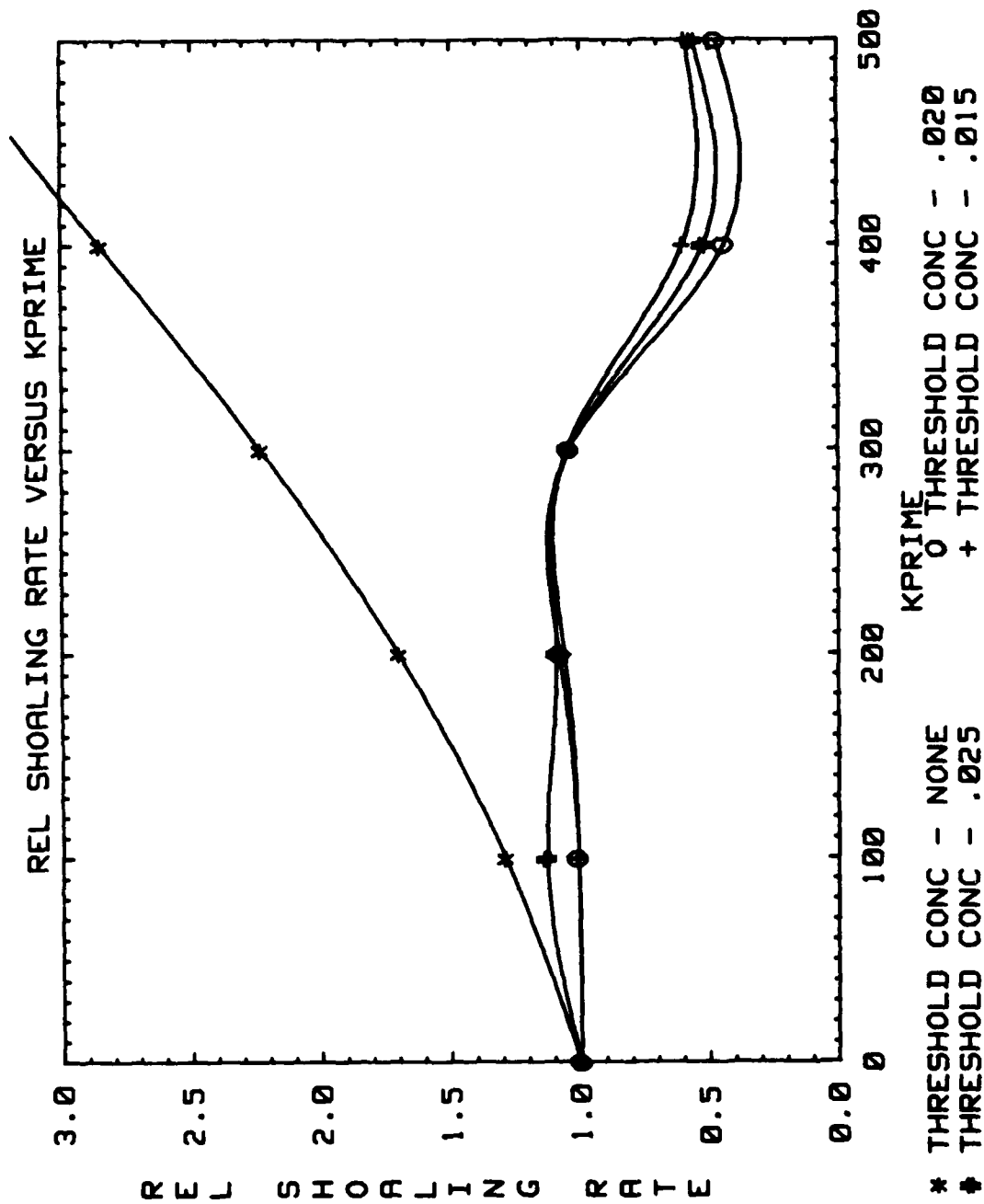


Figure 19. The estimated relative shoaling rate as a function of canal size (Kprime) and duty cycle for the canal gate (assumes no jetty). The duty cycle is adjusted relative to a threshold sediment concentration as depicted in Figure 18.

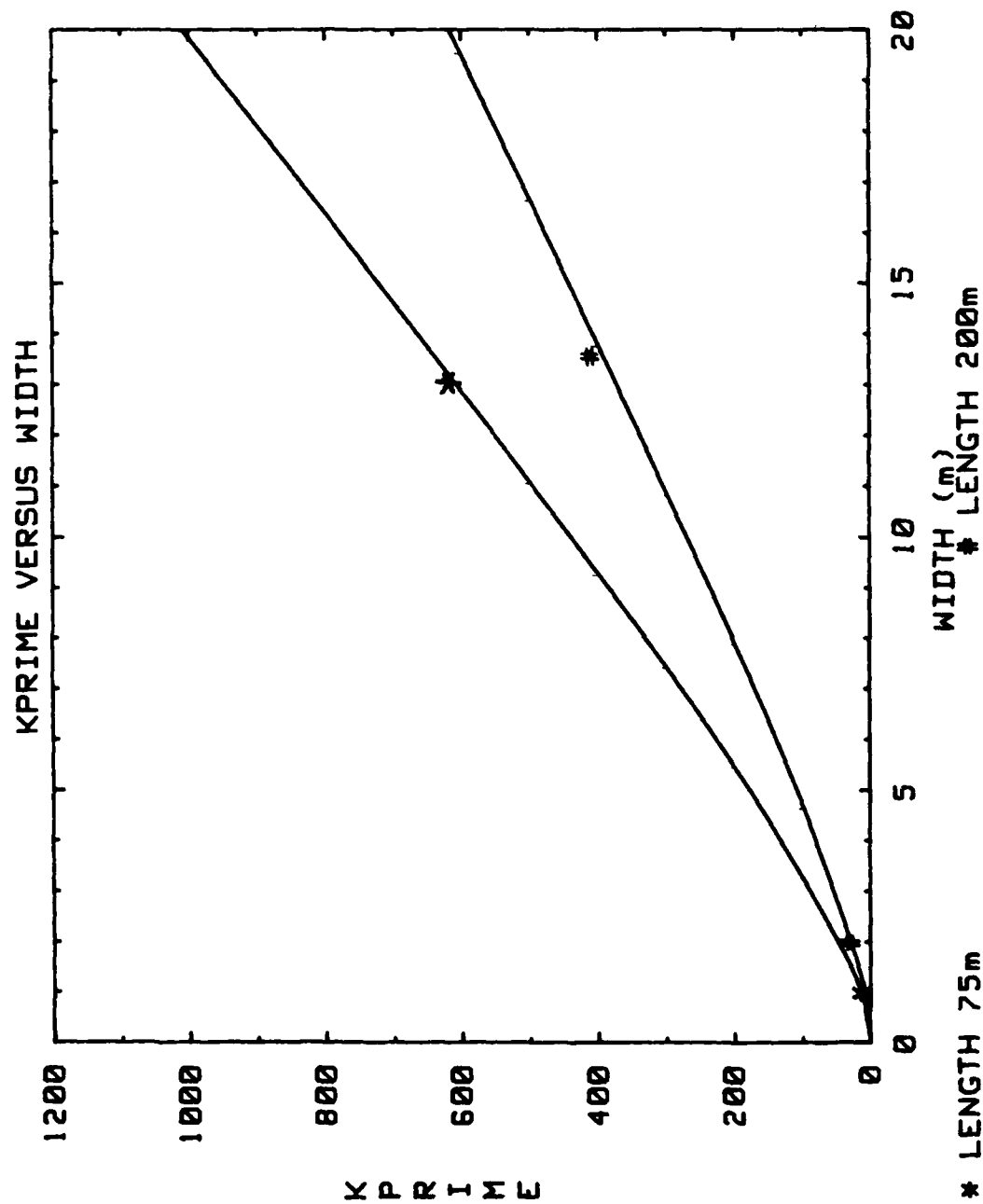


Figure 20. Kprime versus canal width for canal lengths of 75 and 200 meters assuming a 3-meter water depth and rectangular cross-section.

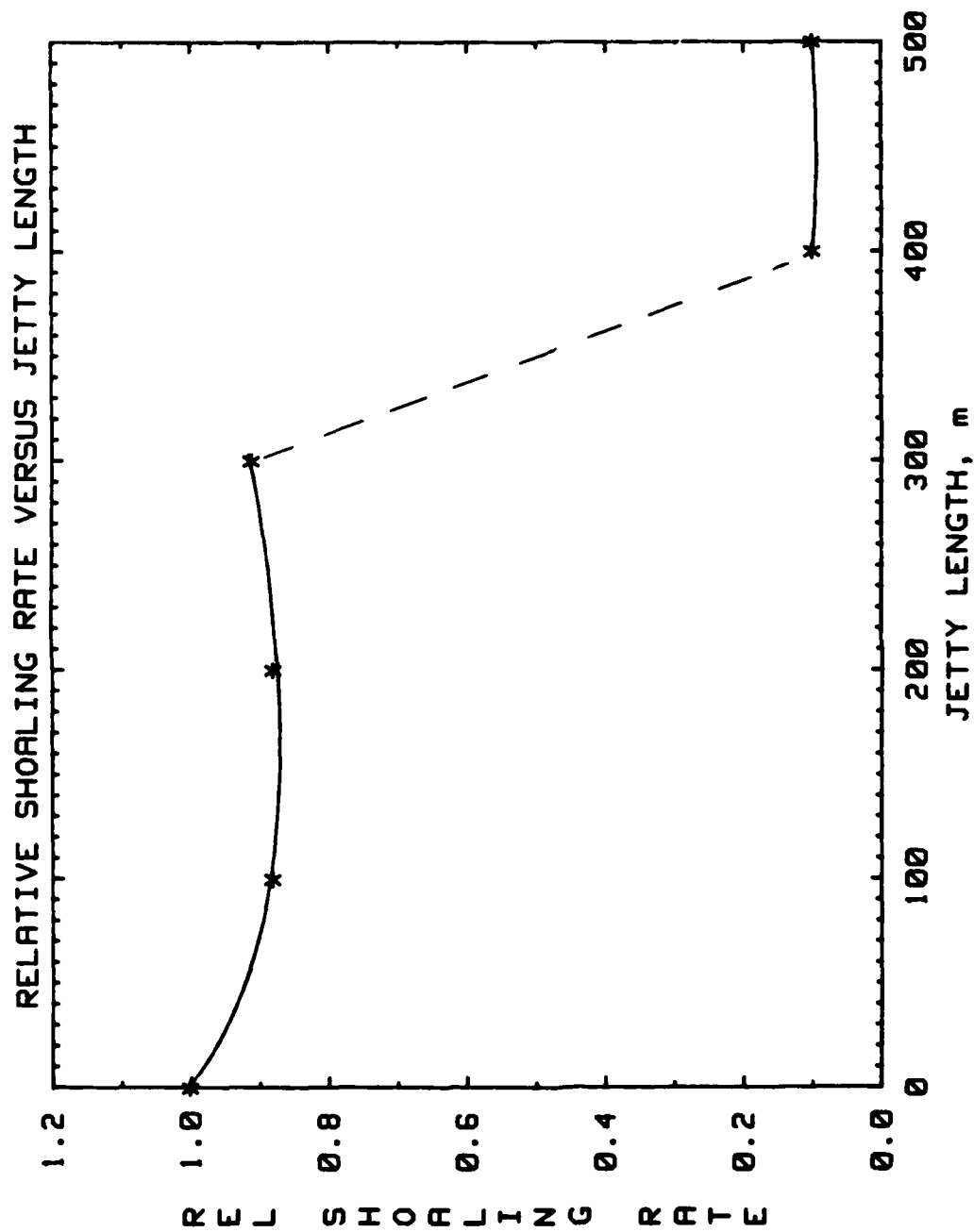


Figure 21. Estimated relative shoaling rate as a function of jetty length (no canal). The minimum acceptable jetty length is 300 to 400 meters.

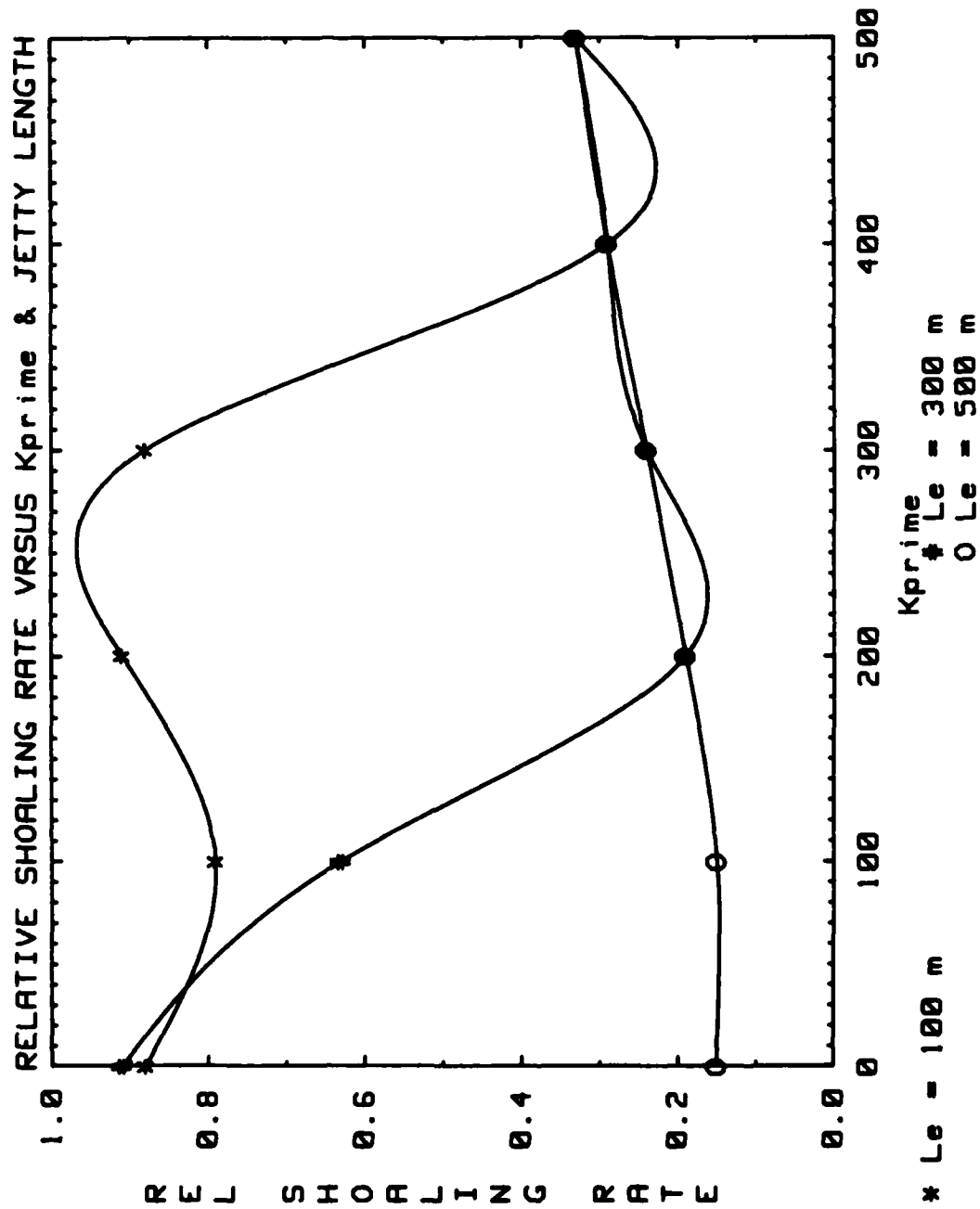


Figure 22. Estimated relative shoaling rate versus canal size (Kprime) for different jetty lengths. A threshold sediment concentration of 0.02 gm/liter was assumed. The minimum shoaling rate occurs with a 500 meter long jetty and no canal.

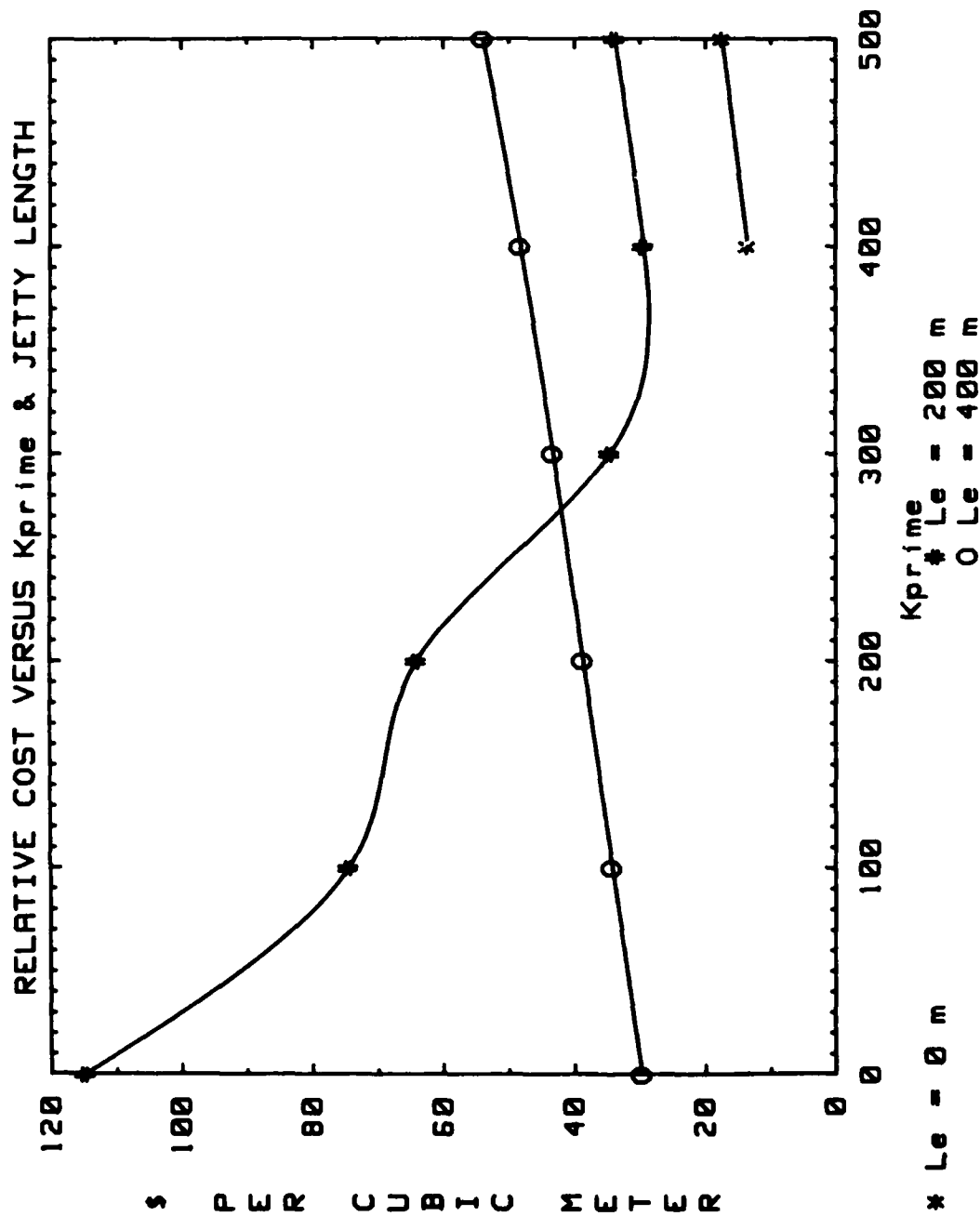


Figure 23. Estimated first cost per cubic meter of reduced annual sedimentation volume versus canal size (Kprime) and jetty length. A threshold sediment concentration of 0.02 gm/liter was assumed. The lowest cost option is a canal without a jetty extension.

DISTRIBUTION LIST

AFESC AFESC/TST, Tyndall AFB, FL
 AFB DET Wright-Patterson OH: HQ MAC/DEEE, Scott, IL; Hq Space Com/Deeq (P. Montoya) Peterson AFB,
 CO: Scol of Engrng (AFIT/DET)
 NATL ACADEMY OF ENG, Alexandria, VA
 ARCTICSUBLAB Code 54, San Diego, CA
 ARMY ARRADCOM, Dover, NJ; BMDSC-RE (H. McClellan) Huntsville AL; DAEN-MPE-D Washington
 DC: HQDA (DAEN-FEE-A)
 ARMY - CERL Spec Assist for MILCON, Champaign, IL
 ARMY COE Philadelphia Dist. (LIBRARY) Philadelphia, PA
 ARMY FESA-E, Fort Belvoir, VA
 ARMY CORPS OF ENGINEERS MRD-Eng. Div., Omaha NE; Seattle Dist. Library, Seattle WA
 ARMY CRREL A. Kovacs, Hanover NH
 ARMY DARCOM Code DRCMM-CS Alexandria VA
 ARMY CORPS OF ENGINEERS HNDED-CS, Huntsville AL; HNDED-FD, Huntsville, AL
 ARMY ENG WATERWAYS EXP STA Coastal Eng Rsrch Cntr, Vicksburg, MS; Library, Vicksburg MS
 ARMY ENGR DIST, Library, Portland OR
 ARMY ENVIRON, HYGIENE AGCY HSE-EW Water Qual Eng Div Aberdeen Prov Grnd MD
 ARMY MATERIALS & MECHANICS RESEARCH CENTER Dr. Lenoe, Watertown MA
 ARMY MTMC Trans Engr Agency MTT-CE, Newport News, VA
 ARMY-MERADCOM DRDME-WC Ft Belvoir VA
 ADMIN SUPU PWO, BAHRIAN
 ASST SECRETARY OF THE NAVY Spec. Assist Submarines, Washington DC
 BUREAU OF RECLAMATION Code 1512 (C. Selander) Denver CO
 CINCPAC Fac Engrng Div (J44) Makalapa, HI
 CINCUSNAVEUR Fleet Civil Engr, London, England
 CNO Code NOP-964, Washington DC; Code OP 323, Washington DC; Code OP 987 Washington DC; Code
 OPNAV 09B24 (H); Code OPNAV 22, Wash DC; Code OPNAV 23, Wash DC; OP-098, Washington, DC;
 OP987J, Washington, DC
 COMNAVRESFOR Code 08, New Orleans, LA
 COMCBLANT Code S3T
 COMFAIRMED SCE, Code N55, Naples IT
 COMFEWSG DET Security Officer (R. Seidman), Washington, DC
 COMFLEACT PWC (Engr Dir), Sasebo, Japan
 COMFLEACT, OKINAWA PWO, Kadena, Okinawa
 COMFLEACT PWO, Sasebo, Japan; SCE, Yokosuka Japan
 COMNAVLOGPAC Code 4318, Pearl Harbor, HI
 COMNAVSUPFORANTARCTICA DET, PWO, Christchurch, NZ
 COMOCEANSYSLANT PW-FAC MGMNT Off Norfolk, VA
 COMOCEANSYPAC SCE, Pearl Harbor HI
 COMRNCF Nicholson, Tampa, FL
 CONTRALANT SCE, Norfolk, VA
 DEFFUELSUPPCEN DFSC-OWE (Term Engrng) Alexandria, VA; DFSC-OWE, Alexandria VA
 DLSIE Army Logistics Mgt Center, Fort Lee, VA
 DOE Wind/Ocean Tech Div, Washington, DC
 DTIC Defense Technical Info Ctr/Alexandria, VA
 DTNSRDC Anna Lab (Code 4120) Annapolis MD; Anna Lab, Code 4121 (R A Rivers) Annapolis, MD
 FAA (Fowler) Code APM-740, Wash, DC
 FOREST SERVICE Engr Staff Washington, DC
 GIDEP OIC, Corona, CA
 GSA Assist Comm Des & Cnst (FAIA) D R Dibner Washington, DC
 KWAJALEIN MISLAN BMDSC-RKL-C
 LIBRARY OF CONGRESS Washington, DC (Sciences & Tech Div)
 MARINE CORPS BASE M & R Division, Camp Lejeune NC; Maint Off Camp Pendleton, CA; PWD - Maint.
 Control Div, Camp Butler, Kawasaki, Japan; PWO Camp Lejeune NC; PWO, Camp Pendleton CA; PWO,
 Camp S. D. Butler, Kawasaki Japan
 MARINE CORPS HQS Code LFF-2, Washington DC
 MCAS Facil. Engr. Div, Cherry Point NC; CO, Kaneohe Bay HI; Code S4, Quantico VA; Facs Maint Dept -
 Operations Div, Cherry Point; Director, Engrg Design Div, Iwakuni, Japan; PWO, Yuma AZ
 MCRD SCE, San Diego CA
 NAF PWO, Atsugi Japan
 NALF OINC, San Diego, CA
 NAVAIREWORKFAC Code 100, Cherry Point, NC
 NARF Code 640, Pensacola FL; Equip Engr Div (Code 61000), Pensacola, FA

NAS CO, Guantanamo Bay Cuba; Code 0L, Alameda, CA; Code 183 (Fac. Plan BR MGR); Code 18700,
 Brunswick ME; Code 18U (ENS P.J. Hickey), Corpus Christi TX; Code 8E, Patuxent Riv., MD; Dir of
 Engrng, PWD, Corpus Christi, TX; Dir. Maint. Control Div., Key West FL; Lead. Chief, Petty Offr.
 PW Self Help Div, Beeville TX; PW (J. Maguire), Corpus Christi TX; PWD - Engr Div, Gtmo, Cuba; PWD
 - Engr Div, Oak Harbor, WA; PWD Maint. Div., New Orleans, Belle Chasse LA; PWD, Code 1821H
 (Pfankuch) Miramar, SD CA; PWD, Maintenance Control Dir., Bermuda; PWO (Code 18.2), Bermuda;
 PWO Belle Chasse, LA; PWO Key West FL; PWO Lakehurst, NJ; PWO Patuxent River MD; PWO, Cecil
 Field FL; PWO, Dallas TX; PWO, Glenview IL; PWO, Oceana, Virginia Bch VA; PWO, So. Weymouth
 MA; PWO., Moffett Field CA; SCE Norfolk, VA; SCE, Cubi Point, R.P; Security Officer, Kingsville TX;
 Security Offr, Alameda CA; Security Offr, Patuxent Riv. MD
 NATL BUREAU OF STANDARDS R Chung Washington, DC
 NATL RESEARCH COUNCIL Naval Studies Board, Washington DC
 NAVACT PWO, London UK
 NAVSUPPACT PWD, Holy Loch UK
 NAVAEROSPREGMEDCEN SCE, Pensacola FL
 NAVAIRDEVCCEN Code 813, Warminster PA
 NAVAIREWKFAC Code 64116, San Diego, CA
 NAVAIRSYSCOM PWD Code 8P (Grover) Patuxent River, MD
 NAVAIRTESTCEN PATUXENT RIVER PWD (F. McGrath, CE), Patuxent River, MD
 NAVAVIONICFAC PW Div Indianapolis, IN
 NAVCHAPGRU Engineering Officer, Code 60 Williamsburg, VA
 NAVCOASTSYSCEN Code 423 Panama City, FL; Code 715 (J Quirk) Panama City, FL; Code 715 (J.
 Mittleman) Panama City, FL; Library Panama City, FL; PWO Panama City, FL
 NAVCOMMAREAMSTRSTA PWO, Norfolk VA; SCE Unit 1 Naples Italy; SCE, Wahiawa HI; Sec Offr,
 Wahiawa, HI
 NAVCOMMSTA Code 401 Nea Makri, Greece; PWD - Maint Control Div, Diego Garcia Is.; PWO, Exmouth,
 Australia
 NAVEDTRAPRODEVCCEN Technical Library, Pensacola, FL
 NAVEDUTRACEN Engr Dept (Code 42) Newport, RI
 NAVELEXSYSCOM Code PME 124-61, Washington, DC; PME 124-612, Wash DC
 NAVEODTECHCEN Tech Library, Indian Head, MD
 NAVFAC PWO, Centerville Bch, Ferndale CA
 NAVFACENGCOM Alexandria, VA; Code 03 Alexandria, VA; Code 03T (Essoglou) Alexandria, VA; Code
 04A1 Alexandria, VA; Code 04M, Alexandria, VA; Code 04T1B (Bloom), Alexandria, VA; Code 04T4 (D.
 Potter) Alexandria, VA; Code 04T5, Alexandria, VA; Code 07A (Herrmann), Alexandria, VA; Code
 09M54, Tech Lib, Alexandria, VA; Code 100, Alexandria, VA; Code 1113, Alexandria, VA
 NAVFACENGCOM - CHES DIV, Code 101 Wash, DC; Code 405 Wash, DC; Code 406 Washington DC; Code
 407 (D Scheesele) Washington, DC; Code FPO-1C Washington DC; Contracts, ROICC, Annapolis MD;
 FPO-1 Washington, DC; Library, Washington, D.C.
 NAVFACENGCOM - LANT DIV, Code 1112, Norfolk, VA; Code 405 Civil Engr BR Norfolk VA; Br Ofc, Dir
 Roosevelt Rds, P.R.; Br Ofc, Dir, Naples, Italy; Library, Norfolk, VA
 NAVFACENGCOM - NORTH DIV, CO; Code 04 Philadelphia, PA; Code 04AL, Philadelphia PA; Code 09P
 Philadelphia PA; Code 11, Phila PA; Code 111 Philadelphia, PA; Code 405 Philadelphia, PA; ROICC,
 Contracts, Crane IN
 NAVFACENGCOM - PAC DIV, (Kyi) Code 101, Pearl Harbor, HI; CODE 09P PEARL HARBOR HI; Code
 2011 Pearl Harbor, HI; Code 402, RDT&E, Pearl Harbor HI; Library, Pearl Harbor, HI
 NAVFACENGCOM - SOUTH DIV, Code 1112, Charleston, SC; Code 406 Charleston, SC; Library,
 Charleston, SC
 NAVFACENGCOM - WEST DIV, 102; Code 04B San Bruno, CA; Library, San Bruno, CA; O9P 20 San
 Bruno, CA; RDT&ELO San Bruno, CA
 NAVFACENGCOM CONTRACTS AROICC, NAVSTA Brooklyn, NY; Colts Neck, NJ; Dir, Eng. Div.,
 Exmouth, Australia
 NAVUSEAWARENGSTA Marine Barracks, Keyport, WA
 NAVFACENGCOM CONTRACTS Eng Div dir, Southwest Pac, Manila, PI; OICC, Southwest Pac, Manila, PI;
 OICC-ROICC, NAS Oceana, Virginia Beach, VA; OICC-ROICC, Balboa Panama Canal; OICC ROICC,
 Norfolk, VA; ROICC Code 495 Portsmouth VA; ROICC Key West FL; DOICC, Siego Garcia Island;
 ROICC, Keflavik, Iceland; ROICC, NAS, Corpus Christi, TX; ROICC, Pacific, San Bruno CA; ROICC,
 Point Mugu, CA; ROICC-OICC-SPA, Norfolk, VA
 NAVMAG Engr Dir, PWD, Guam, Mariana Islands; SCE, Subic Bay, R.P.
 NAVOCEANO Code 3432 (J. DePalma), Bay St. Louis MS; Code 6220 (M. Paige), Bay St. Louis, MS; Library
 Bay St. Louis, MS
 NAVOCEANSYSCEN Code 4473 Bayside Library, San Diego, CA; Code 4473B (Tech Lib) San Diego, CA;
 Code 5204 (J. Stachiw), San Diego, CA; Code 5214 (H. Wheeler), San Diego CA; Code 541 (Bachman) San
 Diego, CA; Code 90 (Talkington), San Diego, CA; Hawaii Lab (R Yumori) Kailua, HI; Hi Lab Tech Lib
 Kailua HI

NAVSEACENPAC Code 32, Sec Mgr. San Diego, CA
 NAVPETOFF Code 30, Alexandria VA
 NAVPGSCOL C. Morers Monterey CA; Code 1424, Library, Monterey, CA; Code 61WL (O. Wilson)
 Monterey CA; E. Thornton, Monterey CA
 NAVPHIBASE CO, ACB 2 Norfolk, VA; Harbor Clearance Unit Two, Little Creek, VA; PWO Norfolk, VA;
 SCE Coronado, SD, CA; UDT 21, Little Creek, VA
 NAVREGMEDCEN PWD - Engr Div, Camp Lejeune, NC; PWO, Camp Lejeune, NC; SCE, Camp
 Pendleton CA; SCE, Guam; SCE, Newport, RI
 NAVSCOLCECOFF C35 Port Hueneme, CA; CO, Code C44A Port Hueneme, CA
 NAVSCSOL PWO, Athens GA
 NAVSEASYSCOM Code 05E1, Wash, DC; Code PMS-396.3211 (J. Rekas) Washington, DC; Code SEA OOC
 Washington, DC; SEA-070C, Washington, DC; SEA05E1, Washington, D.C.
 NAVSECGRUACT PWO Winter Harbor ME; PWO, Adak AK
 NAVSECGRUCOM Code G43, Washington DC
 NAVSHIPREPFAF Library, Guam; SCE Subic Bay; SCE, Yokosuka Japan
 NAVSHIPYD Carr Inlat Acoustic Range, Bremerton, WA; Code 134, Pearl Harbor, HI; Code 202.4, Long
 Beach CA; Code 202.5 (Library), Bremerton, EA; Code 280, Mare Is., Vallejo, CA; Code 280.28
 (Goodwin), Vallejo, CA; Code 380, Portsmouth, VA; Code 440, Bremerton, WA; Code 410, Mare Is.,
 Vallejo CA; Code 440 Portsmouth NH; Code 440, Norfolk; Code 440, Bremerton, WA; Code 457 (Maint.
 Supr.) Mare Island, Vallejo CA; Code 420, Long Beach, CA; Library, Portsmouth NH; PWD (Code 420)
 Dir Portsmouth, VA; PWD (Code 450-HD) Portsmouth, VA; PWD (Code 457-HD) Shop 07, Portsmouth,
 VA; PWD (Code 460) Portsmouth, VA; PWD (Code 903), Long Beach, CA; PWO, Bremerton, WA; PWO,
 Charleston, SC; PWO, Mare Island, Vallejo, CA
 NAVSURFWPNCEN Code W42 (R. Ponzetto), Dahlgren, VA
 NAVSHIPYD SCE, Pearl Harbor HI
 NAVSTA CO Roosevelt Roads P.R. Puerto Rico; Dir Engr Div, PWD, Mayport FL; Dir Mech Engr 37WC93
 Norfolk, VA; Engr. Dir., Rota Spain; Long Beach, CA; Maint. Cont. Div., Guantanamo Bay Cuba; PWD
 (LCDR P.M. Motolenich) Rota Spain; PWD - Engr Dept, Adak, AK; PWD - Engr Div, Midway Is.; PWO,
 Guantanamo Bay Cuba; PWO, Keflavik Iceland; PWO, Mayport FL; SCE, Guam, Marianas; SCE, Pearl
 Harbor HI; SCE, San Diego CA; SCE, Subic Bay, R.P.; Utilities Engr Off, Rota Spain
 NAVSUBASE SCE, Pearl Harbor HI
 NAVSUPPO Security Officer, La Maddalena, Sardinia, Italy
 NAVSURFWPNCEN Code E211 (C. Rouse) Dahlgren, VA; PWO, Dahlgren VA; PWO, White Oak, Silver
 Spring, MD
 NAVTECHTRACEN SCE, Pensacola FL
 NAVWARCOL Dir. of Facil., Newport RI
 NAVWPNCEN Code 2636 China Lake
 NAVWPNSTA (Clebak) Colts Neck, NJ; Code 092, Colts Neck NJ; Code 092, Concord CA; Engrng Div, PWD
 Yorktown, VA; Maint. Control Dir., Yorktown VA
 NAVWPNSTA PW Office Yorktown, VA
 NAVWPNSTA PWD - Maint. Control Div., Concord, CA; PWD - Supr Gen Engr, Seal Beach, CA; PWO Colts
 Neck, NJ; PWO, Charleston, SC; PWO, Seal Beach CA
 NAVWPNSUPPCEN Code 09 Crane IN
 NCBC Code 10 Davisville, RI; Code 15, Port Hueneme CA; Code 156, Port Hueneme, CA; Library, Davisville,
 RI; PWO (Code 80) Port Hueneme, CA; PWO, Davisville RI; Technical Library, Gullport, MS
 NCR 20, Commander; 30, CO, Guam, Marianas
 NMCB 3, SWC D, Wellington; FIVE, Operations Dept; Forty, CO; THREE, Operations Off.
 NOAA (Mr. Joseph Vadas) Rockville, MD; Library Rockville, MD
 NORDA Code 410 Bay St. Louis, MS; Code 440 (Ocean Rsch Off) Bay St. Louis MS
 NRL Code 5800 Washington, DC; Code 5843 (F. Rosenthal) Washington, DC; Code 8441 (R.A. Skop),
 Washington DC
 USCG Civil Engr (Code 2511) Washington, D.C.
 NSC Code 54.1 Norfolk, VA; Code 700 Norfolk, VA; Fac & Equip Div (Code 43) Oakland, CA; SCE Norfolk,
 VA; SCE, Charleston, SC
 NSD SCE, Subic Bay, R.P.
 NUCLEAR REGULATORY COMMISSION T.C. Johnson, Washington, DC
 NUSC DET Code 3322 (Varley) New London, CT; Code EA123 (R.S. Munn), New London CT; Code TA131
 (G. De la Cruz), New London CT
 ONR Central Regional Office, Boston, MA; Code 421 (Code E.A. Silva), Arlington, VA; Code 481, Bay St.
 Louis, MS; Code 700F Arlington VA
 PACMISRANFAC HI Area Bkg Sands, PWO Kekaha, Kauai, HI
 PERRY OCEAN ENG R. Pellen, Riviera Beach, FL
 PHIBCB 1 P&E, San Diego, CA; 1, CO San Diego, CA
 PMTC EOD Mobile Unit, Point Mugu, CA
 PWC CO, (Code 10), Oakland, CA; Code 10, Great Lakes, IL; Code 100, Guam, Mariana Islands; Code 101
 (Library), Oakland, CA; Code 105 Oakland, CA; Code 1013, Oakland, CA; Code 110, Oakland, CA; Code

154 (Library), Great Lakes, IL; Code 200, Great Lakes IL; Code 400, Great Lakes, IL; Code 400, Pearl Harbor, HI; Code 400, San Diego, CA; Code 420, Great Lakes, IL; Code 420, Oakland, CA; Code 424, Norfolk, VA; Code 438 (Aresto), San Diego, CA; Code 500 Norfolk, VA; Code 500, Great Lakes, IL; Code 500, Oakland, CA; Code 505A Oakland, CA; Code 600, Great Lakes, IL; Code 700, San Diego, CA; Code 590, San Diego, CA; Facilities Planning Dept, Code 1011, Pearl Harbor, HI; Library, Guam, Mariana Islands; Library, Norfolk, VA; Library, Pearl Harbor, HI; Library, Pensacola, FL; Library, Subic Bay, R.P.; Library, Yokosuka JA; Maint. Control Dept. Oakland CA; Production Officer, Norfolk, VA; Utilities Officer, Guam, Mariana Islands
 SUPANX PWO, Williamsburg VA
 TVA Smelser, Knoxville, Tenn.
 UCT ONE OIC, Norfolk, VA
 UCT TWO OIC, Port Hueneme CA
 U.S. MERCHANT MARINE ACADEMY Kings Point, NY (Reprint Custodian)
 US DEPT OF INTERIOR Bur of Land Mgmt Code 583, Washington DC
 US GEOLOGICAL SURVEY Off. Marine Geology, Piteleki, Reston VA
 US NATIONAL MARINE FISHERIES SERVICE Highlands NY (Sandy Hook Lab-Library)
 USCG (G-MP-3/USP82) Washington Dc; G-EOE-4 (T Dowd), Washington, DC; Library Hqs Washington, DC
 USCG R&D CENTER CO Groton, CT; D. Motherway, Groton CT; Library New London, CT
 USDA Ext Service (T. Maher) Washington, DC; Forest Products Lab. (R. DeGroot), Madison WI
 USNA ENGRNG Div, PWD, Annapolis MD; Mech. Engr. Dept. (Hasson), Annapolis, MD; PWO Annapolis MD
 USS FULTON WPNS Rep. Offr (W-3) New York, NY
 WATER & POWER RESOURCES SERVICE (Smoak) Denver, CO
 ADVANCED TECHNOLOGY F. Moss, Op Cen Camarillo, CA
 BERKELEY PW Engr Div, Harrison, Berkeley, CA
 CALIF. DEPT OF NAVIGATION & OCEAN DEV, Sacramento, CA (G. Armstrong)
 CALIFORNIA STATE UNIVERSITY (Yen) Long Beach, CA; LONG BEACH, CA (CHELAPATI)
 CITY OF AUSTIN Resource Mgmt Dept (G. Arnold), Austin, TX
 CITY OF LIVERMORE Project Engr (Dackins) Livermore, CA
 COLORADO STATE UNIVERSITY Civil Engr Dept (J. Nelson) Fort Collins, CO; Civil Engr Dept (W.A. Charlie) Fort Collins, CO
 CORNELL UNIVERSITY (Dr. F.Kulnawy) Dept of Civil & Environ Engrng, Ithaca, NY; Ithaca NY (Serials Dept, Engr Lib.)
 DAMES & MOORE LIBRARY Los Angeles, CA
 DUKE UNIV MEDICAL CENTER B. Muga, Durham NC; DURHAM, NC (VESIC)
 FLORIDA ATLANTIC UNIVERSITY Boca Raton, FL (McAllister)
 HARVARD UNIV, Dept. of Architecture, Dr. Kim, Cambridge, MA
 GEORGIA INSTITUTE OF TECHNOLOGY Atlanta GA (B. Mazanti)
 INSTITUTE OF MARINE SCIENCES Morehead City NC (Director)
 IOWA STATE UNIVERSITY Ames IA (CE Dept, Handy)
 WOODS HOLE OCEANOGRAPHIC INST, Woods Hole MA (Winget)
 LEHIGH UNIVERSITY BETHLEHEM, PA (MARINE GEOTECHNICAL LAB., RICHARDS); Bethlehem PA (Fritz Engr, Lab No. 13, Beedle); Bethlehem PA (Linderman Lib, No.30, Flecksteiner)
 MAINE MARITIME ACADEMY CASTINE, ME (LIBRARY)
 MICHIGAN TECHNOLOGICAL UNIVERSITY Houghton, MI (Haas)
 MIT Cambridge MA; Cambridge MA (Rm 10-500, Tech. Reports, Engr. Lib.); Cambridge MA (Whitman); Cambridge, MA (Harleman)
 NATL ACADEMY OF ENG, ALEXANDRIA, VA (SEARLE, JR.)
 NATURAL ENERGY LAB Library, Honolulu, HI
 NEW MEXICO SOLAR ENERGY INST, Dr. Zwibel Las Cruces NM
 NY CITY COMMUNITY COLLEGE BROOKLYN, NY (LIBRARY)
 OREGON STATE UNIVERSITY (CE Dept Grace) Corvallis, OR; CORVALLIS, OR (CE DEPT, BELL); Corvallis OR (School of Oceanography)
 PENNSYLVANIA STATE UNIVERSITY STATE COLLEGE, PA (SNYDER); State College PA (Applied Resh Lab); UNIVERSITY PARK, PA (GOTOLSKI)
 PORT SAN DIEGO Pro Eng for Port Fac, San Diego, CA
 PURDUE UNIVERSITY Lafayette IN (Leonards); Lafayette, IN (Altschaeffl); Lafayette, IN (CE Engr, Lib)
 SAN DIEGO STATE UNIV, I. Noorany San Diego, CA
 SCRIPPS INSTITUTE OF OCEANOGRAPHY LA JOLLA, CA (ADAMS)
 SEATTLE U Prof Schwaegler Seattle WA
 SOUTHWEST RSCH INST King, San Antonio, TX; R. DeHart, San Antonio TX
 STATE UNIV. OF NEW YORK Buffalo, NY; Fort Schuyler, NY (Longobardi)
 TEXAS A&M UNIVERSITY College Station TX (CE Dept, Herbiech); J.M. Niedzwecki, College Station, TX; W.B. Ledbetter College Station, TX
 TEXAS TECH UNIVERSITY Dept of IE (Prof. Ayoub), Lubbock TX
 UNIVERSITY OF ALASKA Doc Collections Fairbanks, AK; Marine Science Inst. College, AK

UNIVERSITY OF CALIFORNIA A-031 (Storms) La Jolla, CA; BERKELEY, CA (CE DEPT. GERWICK);
 BERKELEY, CA (CE DEPT. MITCHELL); Berkeley CA (Dept of Naval Arch.); Berkeley CA (E.
 Pearson); La Jolla CA (Acq. Dept, Lib. C-075A); M. Duncan, Berkeley CA
 UNIVERSITY OF CONNECTICUT Groton CT (Inst. Marine Sci. Library)
 UNIVERSITY OF DELAWARE Newark, DE (Dept of Civil Engineering, Chesson)
 UNIVERSITY OF HAWAII HONOLULU, HI (SCIENCE AND TECH. DIV.)
 UNIVERSITY OF ILLINOIS (Hall) Urbana, IL; Metz Ref Rm. Urbana IL; URBANA, IL (DAVISSON);
 URBANA, IL (LIBRARY)
 UNIVERSITY OF MASSACHUSETTS (Heronemus), ME Dept. Amherst, MA
 UNIVERSITY OF MICHIGAN Ann Arbor MI (Richart)
 UNIVERSITY OF NEBRASKA-LINCOLN Lincoln, NE (Ross Ice Shelf Proj.)
 UNIVERSITY OF NEW HAMPSHIRE DURHAM, NH (LAVOIE)
 UNIVERSITY OF PENNSYLVANIA Philadelphia, PA (Schl of Engr & Applied Science, Roll)
 UNIVERSITY OF RHODE ISLAND Wm. D. Kovacs, Kingston, RI
 UNIVERSITY OF SO. CALIFORNIA Univ So. Calif
 UNIVERSITY OF TEXAS Inst. Marine Sci (Library), Port Arkansas TX
 UNIVERSITY OF TEXAS AT AUSTIN (Prof J.N. Thompson), Dept Civil Engrg; (R. Olson), Dept Civil
 Engrg; Dr. J.E. Breen (ECJ 4.8)
 UNIVERSITY OF WASHINGTON Seattle WA (M. Sherif); Dept of Civil Engr (Dr. Mattock), Seattle WA;
 SEATTLE, WA (APPLIED PHYSICS LAB); SEATTLE, WA (OCEAN ENG RSCH LAB, GRAY);
 SEATTLE, WA (PACIFIC MARINE ENVIRON. LAB., HALPERN); Seattle WA (E. Linger); Seattle,
 WA Transportation, Construction & Geom. Div
 UNIVERSITY OF WISCONSIN Milwaukee WI (Ctr of Great Lakes Studies)
 VENTURA COUNTY PWA (Brownie) Ventura, CA
 VIRGINIA INST. OF MARINE SCI. Gloucester Point VA (Library)
 ALFRED A. YEE & ASSOC. Librarian, Honolulu, HI
 AMETEK Offshore Res. & Engr Div
 APPLIED SYSTEMS R. Smith, Agana, Guam
 ARVID GRANT OLYMPIA, WA
 ATLANTIC RICHFIELD CO. DALLAS, TX (SMITH); Engr Serv Grp (J Machemehi) Dallas, TX
 BATTELLE-COLUMBUS LABS (D. Frink) Columbus, OH
 BECHTEL CORP. SAN FRANCISCO, CA (PHELPS)
 BETHLEHEM STEEL CO. Dismuke, Bethlehem, PA
 BRAND INDUS SERV INC. J. Buehler, Hacienda Heights CA
 BRITISH EMBASSY M A Wilkins (Sci & Tech Dept) Washington, DC
 BROWN & ROOT Houston TX (D. Ward)
 CHEVRON OIL FIELD RESEARCH CO. LA HABRA, CA (BROOKS)
 COLUMBIA GULF TRANSMISSION CO. HOUSTON, TX (ENG. LIB.)
 CONCRETE TECHNOLOGY CORP. TACOMA, WA (ANDERSON)
 CONTINENTAL OIL CO O. Maxson, Ponca City, OK
 DILLINGHAM PRECAST F. McHale, Honolulu HI
 DIXIE DIVING CENTER Decatur, GA
 DRAVO CORP Pittsburgh PA (Wright)
 EASTPORT INTERNATIONAL INC. (J.H. Osborn) Mgr. West Div, Ventura, CA
 EVALUATION ASSOC. INC KING OF PRUSSIA, PA (FEDELE)
 EXXON PRODUCTION RESEARCH CO Houston, TX (Chao)
 FURGO INC. Library, Houston, TX
 GEOTECHNICAL ENGINEERS INC. (R.F. Murdock) Principal, Winchester, MA
 GLIDDEN CO. STRONGSVILLE, OH (RSCH LIB)
 HALEY & ALDRICH, INC. Cambridge MA (Aldrich, Jr.)
 LAMONT-DOHERTY GEOLOGICAL OBSERVATORY Palisades NY (McCoy)
 LIN OFFSHORE ENGRG P. Chow, San Francisco CA
 MARATHON OIL CO Houston TX
 MARINE CONCRETE STRUCTURES INC. MEFAIRIE, LA (INGRAHAM)
 MOBIL R & D CORP Offshore Eng Library, Dallas, TX
 MOFFATT & NICHOL ENGINEERS (R. Palmer) Long Beach, CA
 MUESER, RUTLEDGE, WENTWORTH AND JOHNSTON New York (Richards)
 EDWARD K. NODA & ASSOC Honolulu, HI
 NEW ZEALAND New Zealand Concrete Research Assoc. (Librarian), Porirua
 NEWPORT NEWS SHIPBLDG & DRYDOCK CO. Newport News VA (Tech. Lib.)
 PACIFIC MARINE TECHNOLOGY (M. Wagner) Duvall, WA
 PORTLAND CEMENT ASSOC. SKOKIE, IL (CORLEY; SKOKIE, IL (KLIEGER); Skokie IL (Rsch & Dev
 Lab, Lib.)
 R J BROWN ASSOC (R. Perera), Houston, TX
 RAYMOND INTERNATIONAL INC. E Colle Soil Tech Dept, Pennsauken, NJ; J. Welsh Soiltech Dept,
 Pennsauken, NJ

SANDIA LABORATORIES Library Div., Livermore CA; Seabed Progress Div 4536 (D. Talbert) Albuquerque NM
 SCHUPACK ASSOC SO. NORWALK, CT (SCHUPACK)
 SEAFOOD LABORATORY MOREHEAD CITY, NC (LIBRARY)
 SEATECH CORP. MIAMI, FL (PERONI)
 SHANNON & WILLSON INC. Librarian Seattle, WA
 SHELL DEVELOPMENT CO. Houston TX (C. Sellars Jr.); Houston TX (E. Doyle)
 SHELL OIL CO. HOUSTON, TX (MARSHALL); I. Boaz, Houston TX
 SIMPSON GUMPERTZ & HEGER INC Consulting Engrs (E. Hill) Arlington, MA
 TIDEWATER CONSTR. CO Norfolk VA (Fowler)
 TILGHMAN STREET GAS PLANT (Sreas), Chester, PA
 UNITED KINGDOM LNO, USA Meradcom, Fort Belvoir, VA
 WESTINGHOUSE ELECTRIC CORP. Annapolis MD (Oceanic Div Lib, Bryan)
 WESTINSTRUCORP Egerton, Ventura, CA
 WISS, JANNEY, ELSTNER, & ASSOC Northbrook, IL (D.W. Pfeifer)
 WM CLAPP LABS - BATTELLE DUXBURY, MA (LIBRARY)
 WOODWARD-CLYDE CONSULTANTS (Dr. R. Dominguez), Houston, TX; Library, West. Reg., Walnut Creek, CA; (R. Cross), Walnut Creek, CA
 ANTON TEDESKO Bronxville NY
 BARA, JOHN P. Lakewood, CO
 BARTZ, J Santa Barbara, CA
 BULLOCK La Canada
 DOBROWOLSKI, J.A. Altadena, CA
 F. HEUZE Alamo, CA
 F.W. MC COY Dr. F.W. McCoy, Woods Hole, MA
 BEN C. GERWICK, INC San Francisco, CA
 LAYTON Redmond, WA
 CAPT MURPHY Sunnyvale, CA
 MARINE RESOURCES DEV FOUNDATION N.T. Monney, Annapolis, MD
 MESSING, D.W. Voorhees, NJ
 OSBORN, JAS. H. Ventura, CA
 PAULI Silver Spring, MD
 PETERSEN, CAPT N.W. Camarillo, CA
 R.F. BESIER Old Saybrook CT
 SMITH Gulfport, MS
 SPIELVOGEL, LARRY Wyncote PA
 T.W. MERMEL Washington DC

PLEASE HELP US PUT THE ZIP IN YOUR
MAIL! ADD YOUR FOUR NEW ZIP DIGITS
TO YOUR LABEL (OR FACSIMILE),
STAPLE INSIDE THIS SELF-MAILER, AND
RETURN TO US.

(fold here)

DEPARTMENT OF THE NAVY

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043-5003

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE, \$300
1 IND-NCEL-2700/4 (REV. 12-79)
0030-LL-L70-0044

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DOD-216



Commanding Officer
Code L14
Naval Civil Engineering Laboratory
Port Hueneme, California 93043-5003

INSTRUCTIONS

The Naval Civil Engineering Laboratory has revised its primary distribution lists. The bottom of the mailing label has several numbers listed. These numbers correspond to numbers assigned to the list of Subject Categories. Numbers on the label corresponding to those on the list indicate the subject category and type of documents you are presently receiving. If you are satisfied, throw this card away (or file it for later reference).

If you want to change what you are presently receiving:

- Delete — mark off number on bottom of label.
- Add — circle number on list.
- Remove my name from all your lists — check box on list.
- Change my address — line out incorrect line and write in correction (**ATTACH MAILING LABEL**).
- Number of copies should be entered after the title of the subject categories you select.

Fold on line below and drop in the mail.

Note: Numbers on label but not listed on questionnaire are for NCEL use only, please ignore them.

Fold on line and staple.

DEPARTMENT OF THE NAVY

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, \$300
1 INB-NCEL-2700/4 (REV. 12-78)
0000-LL-L70-0044

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DOD-216



Commanding Officer
Code L14
Naval Civil Engineering Laboratory
Port Hueneme, California 93043

DISTRIBUTION QUESTIONNAIRE

The Naval Civil Engineering Laboratory is revising its primary distribution lists.

SUBJECT CATEGORIES

- 1 SHORE FACILITIES
- 2 Construction methods and materials (including corrosion control, coatings)
- 3 Waterfront structures (maintenance/deterioration control)
- 4 Utilities (including power conditioning)
- 5 Explosives safety
- 6 Construction equipment and machinery
- 7 Fire prevention and control
- 8 Antenna technology
- 9 Structural analysis and design (including numerical and computer techniques)
- 10 Protective construction (including hardened shelters, shock and vibration studies)
- 11 Soil/rock mechanics
- 13 BEQ
- 14 Airfields and pavements
- 15 ADVANCED BASE AND AMPHIBIOUS FACILITIES
- 16 Base facilities (including shelters, power generation, water supplies)
- 17 Expedient roads/airfields/bridges
- 18 Amphibious operations (including breakwaters, wave forces)
- 19 Over-the-Beach operations (including containerization, material transfer, lightering and cranes)
- 20 POL storage, transfer and distribution
- 24 POLAR ENGINEERING
- 24 Same as Advanced Base and Amphibious Facilities, except limited to cold-region environments

28 ENERGY/POWER GENERATION

- 29 Thermal conservation (thermal engineering of buildings, HVAC systems, energy loss measurement, power generation)
- 30 Controls and electrical conservation (electrical systems, energy monitoring and control systems)
- 31 Fuel flexibility (liquid fuels, coal utilization, energy from solid waste)
- 32 Alternate energy source (geothermal power, photovoltaic power systems, solar systems, wind systems, energy storage systems)
- 33 Site data and systems integration (energy resource data, energy consumption data, integrating energy systems)
- 34 ENVIRONMENTAL PROTECTION
- 35 Solid waste management
- 36 Hazardous/toxic materials management
- 37 Wastewater management and sanitary engineering
- 38 Oil pollution removal and recovery
- 39 Air pollution
- 40 Noise abatement
- 44 OCEAN ENGINEERING
- 45 Seafloor soils and foundations
- 46 Seafloor construction systems and operations (including diver and manipulator tools)
- 47 Undersea structures and materials
- 48 Anchors and moorings
- 49 Undersea power systems, electromechanical cables, and connectors
- 50 Pressure vessel facilities
- 51 Physical environment (including site surveying)
- 52 Ocean-based concrete structures
- 53 Hyperbaric chambers
- 54 Undersea cable dynamics

TYPES OF DOCUMENTS

- | | | | |
|-------------------------------------|------------------------------------------|-------------------------|--------------------------------------------------|
| 85 Techdata Sheets | 86 Technical Reports and Technical Notes | 82 NCEL Guide & Updates | <input type="checkbox"/> None—
remove my name |
| 83 Table of Contents & Index to TDS | | 91 Physical Security | |

END

FILMED

10-85

DTIC